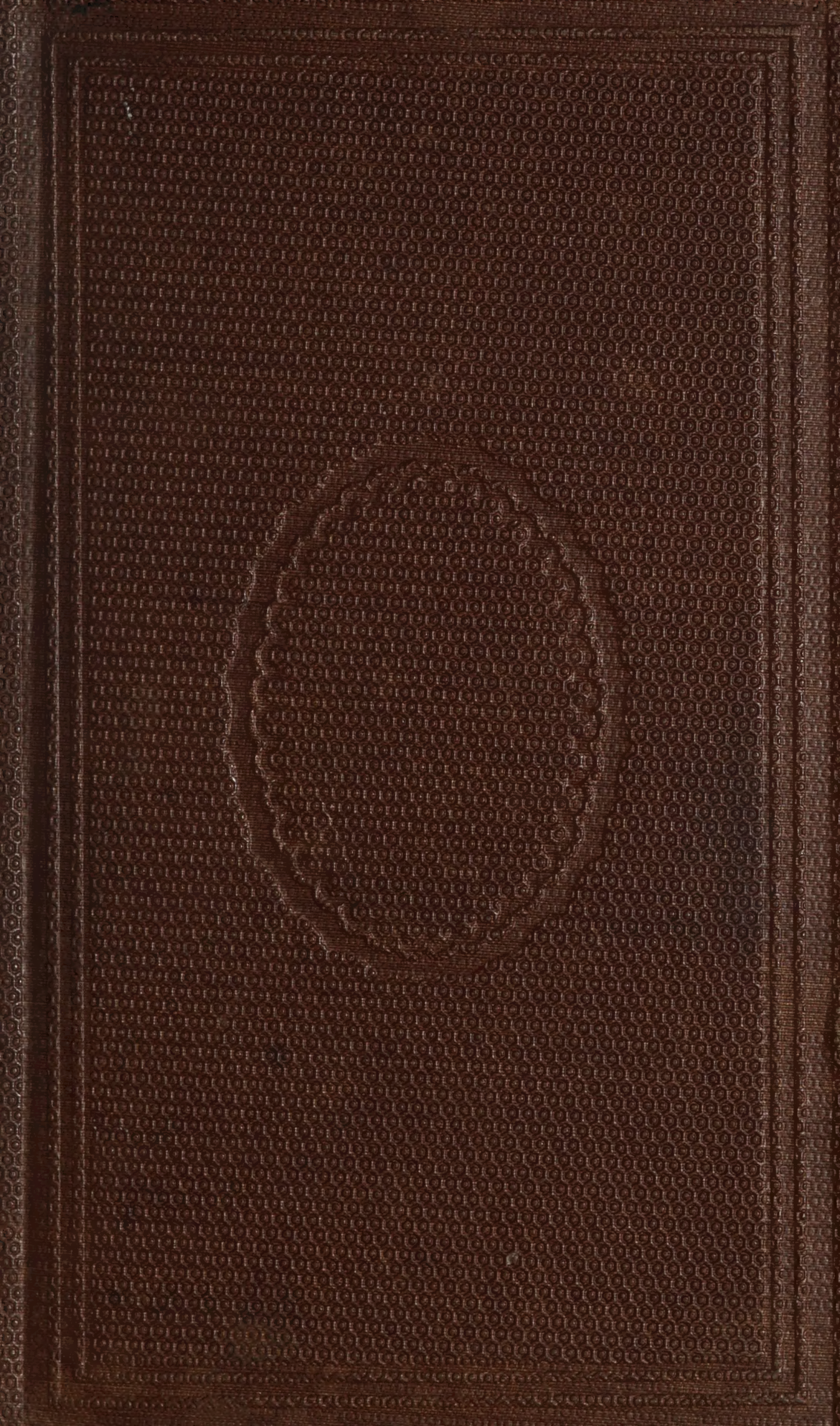
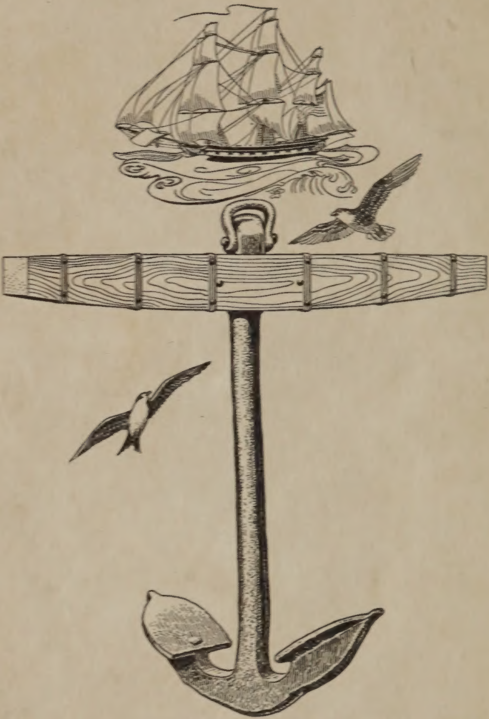


Cat'l.



E.I.M.S. 1799
THE MARINE ROOM
PEABODY MUSEUM
SALEM MASSACHUSETTS

Purchased - 1931.

1090.1
Ny TE

Property of
G J Lawler
35. Walnut Street
Chelsea Jany 29th
1877

ON
TECHNOLOGICAL EDUCATION
AND
SHIPBUILDING,
FOR
NAVAL AND MARINE ENGINEERS.

BY

JOHN W. NYSTROM,
LATE ACTING CHIEF ENGINEER UNITED STATES NAVY.

PEABODY MUSEUM OF SALEM

PHILADELPHIA:
HENRY CAREY BAIRD,
INDUSTRIAL PUBLISHER,
406 Walnut Street.
1865.

c

Entered according to Act of Congress, in the year 1865, by
HENRY CAREY BAIRD,
in the Clerk's Office of the District Court of the United States
in and for the Eastern District of Pennsylvania.

PEABODY MUSEUM OF SALEM

1090.1
N998

PHILADELPHIA:
COLLINS, PRINTER.

PREFACE.

MUCH consideration has been given to the propriety of publishing the accompanying views on technological education, as they were originally not intended for that purpose; but as some steps must be taken in that direction before long, in compliance with what many deem an imperious public necessity, the hesitation was at length relinquished. In order to render the necessity of technological education more conspicuous, occasional reference has been made to actual cases of engineering disappointments and mismanagement, growing out of a want of applied science. Engineers are often intrusted with responsible stations, without being possessed of adequate knowledge of their profession, or without having gradually and fairly earned such appointment in the field of experience. It is not yet time to attempt to classify the rank and position of engineers in the several departments, civil and military, on land and sea, which, for obvious reasons, must be deferred until a proper time.

The relation between engineers and sailing officers on board of steamers has, in all countries, been a troublesome question, ever since the introduction of steam. The engineer knows himself to be in a very responsible position, not always appreciated by his captain. He is often of very limited education, and when he finds himself imposed upon, perhaps inadvertently uses stronger language than necessary in his defence, which has often been the cause of much discord.

Education is necessary to the engineer, not, however, principally for enabling him to please the captain, but for the proper performance of his professional duty generally, and he will, at the same time, accord and harmonize better with the sailing officers by whom he is surrounded.

The Corps of Engineers in the United States

Navy is on a better footing than that of any one in Europe, but, nevertheless, it does not enjoy the standing due to its important office, either in respect to its rank or its education. The United States Navy has now taken the lead in the new tactics of naval warfare, and, through a decisive experience, has developed the necessity of making a corresponding change in its executive organization, as regards the rank and learning of its engineers.

What is required here cannot be learned in foreign countries, for whilst our present experience is far ahead of theirs, neither their practical knowledge nor their accepted theories are sufficient or altogether applicable to our case. It is therefore necessary for the Corps of Engineers, relying only upon their characteristic enterprise and independence of mind, to carry their achievements still further onwards, and by qualifying themselves to maintain with dignity their appropriate rank in the service, at the same time preserve their well-earned position as pioneers in their professional career.

The writer has for many years felt the

greatest interest in the progress and standing of this Corps, and respectfully begs leave to submit herewith for their consideration, some views on this subject, some parts of which have already been communicated to the Congressional Committees on Naval Affairs, as also a further communication to the Secretary of the Navy.

JOHN W. NYSTROM.

CONTENTS.

On Technological Education 13
The knowledge of Steam-Engineering behind the knowledge of science 14
Failure of Steamers for a want of applied science 15
Fresh water condensors, and combustion of fuel . 16
Knowledge of Steamship performance . . . 17
Expansion experiments made by the Navy Department 18
Natural effect of Steam or maximum work per unit of heat 19
Natural effect of Steam-Engines 20
Nystrom's Pocket-Book 21
Reform wanted in our scientific books . . . 23
America has taken the lead in popular education . 25
Technological Institutions wanted . . . 26
The National Academy of Science . . . 27
Object of Technological Institutions . . . 29
Steam-Engineering and Shipbuilding 30
Necessity of complete drawings before the building of steamers is commenced 31

America has taken the lead in the new naval tactics 33
The Naval Academy, at Annapolis, not proper for a school of Steam-Engineering 36
Want of applied science in our workshops . . 38
Locomotive engineering 39
Communication to the Secretary of the Navy on the science of Shipbuilding 41
Shipbuilders consider their art a craft . . . 43
Shipbuilders' jealousy 46
Shipbuilding developed to the condition of a science 47
Memorandum 51
Chief-Engineer Isherwood does not approve the Parabolic Construction of Ships 51
On the Parabolic Construction of Ships . . 55
Application of the Parabolic Construction of Ships 73
Recording formulas 75
Recording tables 77
The labor of calculating the shipbuilding tables . 82
Mr. W. L. Hanscom, Naval Constructor, on the Parabolic Method 84
Mr. J. Vaughan Merrick on the Parabolic Construction 85
Resignation, by the Author, as Acting Chief Engineer in the Navy 86

Memorandum 89
The science of dynamics in a confused condition . 90
Illustrations required in dynamics 94
Mr. Isherwood declines having the subject of dynamics cleared up 94
The subject of dynamics submitted to the National Academy of Science 95
Washington Navy Yard 97
Engineers in the Navy Department . . . 99
Captain Fox on Engineering and Construction of ships 100
Secrecy respecting ships' drawings . . . 102
Steamboiler explosions 104

TO THE

CHAIRMAN OF THE COMMITTEE

OF

NAVAL AFFAIRS, U. S. CONGRESS,

WASHINGTON, D. C.

SIR: The object of this paper is to invite the attention of your Committee, and of Congress, to a subject of general interest to the country, and one of particularly great importance to the power and prosperity of its navy.

The subject is that of establishing a *Technological Academy for Naval Engineers*, and for the *promotion of sciences* bearing on the immediate necessities of the country in that Department. Should it receive your Committee's attention and approbation, and should you consider it worthy of being submitted to Congress, the undersigned is willing to suggest the requisite plans and method for its organization.

I have the honor to remain,
Your obedient servant,
JOHN W. NYSTROM,
Engineer.

MARKOE HOUSE,
PHILADELPHIA, Dec. 21, 1863.

ON

TECHNOLOGICAL EDUCATION.

The immense natural resources of the New World are confided to the hands of an enterprising, ingenious, and happy people; yet their time, their money, their life, and their credit, in imitation of the Old World, are lavishly wasted, through a deficient knowledge of those physical laws which constitute the most essential element of all human enterprise. Under this impression the writer has striven, by means of various scientific articles on these subjects, to enforce the necessity of enlarged reform, both in the study and the application of these laws, which he modestly hopes may have some good effect.

The efforts of a single individual, however, when elevated to subjects of such magnitude, only result in perpetual and unprofitable struggles with organized interests and prejudices, and fail of their purpose through the misconceptions which are inseparable from new and original subjects. From its novelty alone, a new and valuable idea is frequently condemned on bare supposition, and the writer has thus labored in vain, under the greatest disadvantages (accompanied with great expense), to rescue the proposition which he is now about to submit to your committee, from that neglect to which, for many years, it has been doomed by the indifference or imperfect appreciation of those around him.

Up to the present day, the knowledge of steam engineering, in which we take so much pride, and which constitutes a most essential part of our national existence, is far behind our general knowledge of science. Our marine engines and boilers are not only unnecessarily complicated, but prodigally extravagant in their consumption of fuel; whilst not unfrequently new machinery fails to accomplish expected results from the want of knowledge of the physical laws bearing on the problem.

Only a few years ago there was not a single "steam propeller" in the United States with properly constructed air-pumps and foot-valves. Some of the propellers designed to go to Europe succeeded in making one passage, whilst others broke down at but a short distance from the shore, and returned; most of them existed but a short time, and involved the loss of millions of dollars to the country, to say nothing of the effect upon its scientific and mechanical reputation. Enterprising merchants, who attempted to establish lines of steamers to Europe, became discouraged, and perhaps ruined by their failure, and the result now is that we have not a single steamer in the European trade. A few names of steamers may be referred to in verification of these remarks—namely, the frigate *San Jacinto*, which broke down through disarrangement of her air-pumps and foot-valves; the *La Fayette* also (whose machinery contained perhaps the worst air-pumps ever constructed); the *City of Petersburg; Ben Franklin;* and the *Frigate Merrimac*, which suffered from the breaking down of her foot-valves on her passage from America to England, in 1856, and which had to be improved in England. In addition to these, a great many other first-class American steamers experienced the same fate for want of *applied physical science.*

When the writer became acquainted with these defects, he attempted to correct them by explaining the physical laws in operation, which, at the time, was only received with ridicule, and derided as theoretical. He then worked out practical formulas, which were published in the Journal of the Franklin Institute, of Philadelphia, and in his "Pocket-Book of Engineering," giving a solution of the principles under which the air-pump and foot-valves operate, after which many errors were corrected; but up to the present day there is no other publication on the subject. That publication has been copied and republished in Europe.

Blunders of this kind are still going on, by means of which millions of dollars are wasted, and our national reputation impaired from this general want of applied *physical science.*

The physical laws connected with the operation of fresh water or surface condensers, with the combustion of fuel, with the nature and properties of steam; with the dynamic equivalent, the conducting economy, and other properties of heat, are yet but partly known, and that by but a few scientific men in the world; and in no case are they worked out to a practical shape, with formulas intelligible to the engineers in the shop.

We find by science that the theoretical effect of *one pound* of pure carbon consumed per hour, is over *five horses*, whilst in our present practice it requires several pounds of coal per hour for each horse power.

Fresh water condensers have always given trouble; the combustion of fuel requires most earnest attention, not so much for the cost of fuel, as to enable us to navigate long distances with great speed, and with something more on board than boilers, machinery, and fuel. The Navy Department is now having steamers built intended for great speed, the arrangements of which plainly show a want of proper knowledge in steamship performance.

The knowledge of steamship performance is yet at a very low point, and for want of it no accurate record can be kept, by which to compare the true quality of performance of one steamer with that of another; or to determine what will be the performance of a steamer constructed according to given data.

Ingenious contrivances in machinery and steamers, with plausible promises of high speed (up to twenty and thirty miles per hour), are frequently met with, whose plans, sometimes confidently accepted, often result in complete failure and disappointment, which properly applied science would have avoided. The truth of this observation will probably be realized by a wild scheme now before the City Councils of Philadelphia, proposing a line of steamers to Europe, which has for several years remained in a nebulous condition, unsupported by that scientific reasoning by which alone any one could be rendered confident of the result.

Some twelve years ago, the writer was compiling a Pocket-Book of Mechanics and Engineering (since published in repeated editions); he analyzed many previously published data, and, with the aid of his own experience, reduced the law of steamship performance to a practical rule to work by. In one of the most respectable journals of the country were found some plausible data on steamship performance, which threw the writer into the utmost confusion, and in their solution involved him in great expense of travel and practical investigation, only to find them bold exaggerations.

The Navy Department have made very extensive experiments on the expansion of steam, which were commenced in New York some four years ago. The well-known Erie expansion experiments, the Washington Navy Yard and Old Point boat experiments, and the expansion experiments made lately at the Novelty Iron Works, N. Y., were all carried on in the apparent attempt to overthrow natural laws, and establish physical by-laws. The engineers are manifestly not familiar with the scientific principles which belong to the question.

The natural effect in a given quantity of steam, of given temperature and pressure, is as specific as the natural effect in a waterfall. We have only to strive, by improvements in the arrangement of our steam-engines and boilers, to utilize the greatest possible percentage of that natural effect, as is done by water-wheels and turbines. If the Navy Department find no utility in the expansion of steam, it only exposes its position in the science of steam engineering, which can be no indication of what may be done by other parties.

Steam-engines, like water-wheels and turbines, utilize widely different percentages of the natural effect, even with equal grade of expansion, which may be seen in the results of the different experiments made on different engines by the Navy Department. The result of each experiment is applicable only to that peculiar arrangement of the engine and boiler experimented upon, and no more.

The maximum or natural work K, per unit of heat in steam, is in footpounds.

$$K = \frac{144\,P\,(V-1)\,(2{\cdot}3\ log.\frac{S}{l}+1)^{*}}{H'\,V}.$$

---

* See Nystrom's Pocket-Book, 10th edition, for the value of these quantities.

$P =$ total steam pressure per square inch.

$H' =$ units of heat per cubic foot of the steam P.

$V =$ volume of the steam compared with water.

$S =$ stroke of steam-piston, in inches.

$l =$ part of the stroke under which steam is fully admitted, in inches.

The natural effect of the heat in the steam in horse-power, will be—

$$= \frac{N K}{550 \; T}.$$

$N =$ total number of units of heat passed through the steam engine in the time T in seconds. The more of this natural effect that can be utilized, the more perfect is the steam-engine. It is time to speak about steam-engines as we do about water-wheels and turbines—namely, "how many per cent. it utilizes of the natural effect."

On the writer's last arrival from Europe, Dec. 1860, he found the anti-expansion question receiving considerable attention by engineers. He published, in a scientific journal, some demonstrations to prove the folly of the Erie expansion experiments; and, although ridiculed in a New York paper, they produced good effect. Again, he published in his Pocket-Book tables for expansion of steam (hitherto the most complete in print), and its connection with superheated steam, which also had a great effect, as subsequent experiments resulted in their favor.

The Navy Department is here alluded to because their blunders are more perfectly exposed to view, and therefore better known, but the evil is none the less serious in private enterprises.

The writer is in possession of knowledge which would greatly contribute to clear up these difficulties, and advance the character of our steam engineering, but he cannot undertake the great expense of bringing it before the public, inasmuch as scientific knowledge is not sufficiently diffused among our mechanics and engineers to render such a work self-sustaining. In proof of which he would remark that publishers are not willing even to get up such expensive books as his "Pocket-Book of Mechanics and Engineering," of which copies are sent herewith.

The manuscript of this book was submitted to publishers in the year 1853, some of whom had it examined by scientific and practical men, who condemned it as useless, and unfit for publication. Some publishers objected to the great expense in bringing it out, whereupon it was carried through at the author's own expense, which now amounted to a considerable sum. The small profit realized is not sufficient for the expense of experiments and investigation attending each succeeding edition.

I take it for granted that, in a matter so important to the profession and the country, many others, much more highly qualified by their abilities and attainments than myself, would cheerfully co-operate in the efforts to further the main purpose here foreshadowed, if an organized shape could only be given to it, or a nucleus of some kind formed upon which their efforts would be concentrated; and in view of the great expense attending it, I consider it necessary, in due regard to the interests of the engineering profession, to lay the matter before your committee, trusting that it may receive due consideration, and that, possibly, means may be appropriated for that purpose.

The labor attending the investigation of new and original subjects is immense; particularly in exploring unknown regions of science, and bringing the product home to simple formulas and tables of a practical shape. There does not, at present, appear to be any one among us who is willing or able, perhaps, for want of time, to undertake such a laborious task, and very few know what is wanted, but too many suppose we have attained perfection.

We have plenty of scientific books, mostly written by professors in colleges, having very little or no opportunity to apply their knowlege in practice, and which are, therefore, destitute of practical examples.

We frequently find most valuable formulas given by scientific men in such a shape that it requires to know more than the author in order to employ them; they are not only not trimmed to a practical shape, but even the meaning of letters is rarely explained in a technical language.

It is surprising to see how successfully mathematicians have contrived to keep the simple science of the "calculus" such a perfect mystery. It reaches very few among us, not from difficulty in learning it, but simply for want of its judicious application in practice. We find books on the calculus of several hundred pages without a single practical example, which makes the science difficult and tedious of acquisition, and when acquired, very rarely further developed, but is stored away in the mind so that it cannot be found when wanted. We find simple formulas occupying several pages in explanation, which, by a solitary example applied to practice, would imprint it indelibly upon the student's memory. All this can be effectually corrected and improved by the establishment of proper institutions for the instruction of combined theory and practice.

There is now a very distinct line drawn between scientific and practical men; the more we study and cultivate the branches separately, the more distinct will this line become, and the less will they understand one another, and may ultimately fall into irreconcilable estrangement. The prejudice against science is, in our day, a very serious evil.

Science is almost despised by many practical men, not always for want of valuation of it, but often because they do not understand it. A blind man can walk on roads and streets, but when he finds an obstacle must stop; at a ditch he may tumble down into it, he cannot turn from his accustomed track. Such is the case with many practical and otherwise most valuable men working without a knowledge of physical laws. In order to follow up the improvements of the age, the track pursued by our fathers must often be abandoned, and a new one selected and surveyed for ourselves.

Without the application of science we go ahead without knowing where we are going. In verification of which we have plenty of examples in engineering blunders, sometimes subjected to a committee of inquiry, which may result in the discharge of the engineer, accompanied by extravagant abuse of the department concerned, and the evil only temporarily remedied by substituting another, who will most likely not repeat the same blunders, but will do something worse. There is yet no attempt made to permanently remove these evils and secure success in our enterprises by proper institutions. This your committee will admit to be true, but may ask "how can the evil be removed and permanently corrected?"

America has taken the lead of the world in popular education. Its institutions are copied and imitated in Europe, but it remains for us to follow up and take the lead in the nobler and purer refinement of our nature. We have the best materials in the world by which to accomplish this object, the question is only as to the time and the means to be taken.

We are a new people; our habits and circumstances are different from those of other nations, and our institutions must be organized accordingly.

In Europe they have institutions for the diffusion of combined theoretical and practical learning, the want of which is most severely felt in this country. Institutions of that kind are of more importance in America than elsewhere, for the reason that mechanical skill and inventive ingenuity are here more extensively developed, and the want of applied science wastes away a proportionate quantity of time and money.

It is very evident that we are behind some other nations in science, and, at the same time, it is certain that we have more science than we can properly manage or utilize. It is the *application of science to practice* which requires immediate attention and special institutions.

It is very gratifying to know that Congress, at its last session, passed a bill to establish a *National Academy of Science*, which will no doubt be of great value; but how can it be brought to bear advantageously on the general interest and immediate wants of the country?

Considering the peculiar circumstances in which the country is now placed (the natural fruit of time and civilization), technological institutions are absolutely necessary to enable us to rise gradually and surely to the position due to us among nations, and, when once so raised, we would never fall, but become able to maintain with true dignity a *National Academy of Science.*

Technological institutions will reveal and develop the talent and ability of the nation, and bring its immense natural resources to account. It is technological institutions which alone furnish *proper materials* for a National Academy of Science. We have now among us many Newtons, Keplers, Berzelius's, Watts's, Fultons, &c. &c., but have no means of bringing them out; but, on the contrary, plenty of ingenious contrivances to screen them from observation. They are not willing to enter into competition with our everyday rivals, while our national leaders, in their most earnest exertion to find the right man for the right place, are continually imposed upon. This evil cannot be removed by the peculiar liberty alone, in which we take so much pride, but simply by a diffusion of useful knowledge through established institutions, which should constitute the true object of our national pride.

At the present time, scientific attainments and true practical knowledge are very little respected; physical laws established by the creator of the universe, are often derided as theoretical; ignorance has taken the lead, and rules in the ascendant, and often adopts that which is opposite alike to science, experience, and common sense.

The object of this paper, therefore, is to propose the establishment of a *National Technological Academy* of high order, whose purpose should be by the combination of practical and theoretical instruction, to subserve a great public want, and at the same time to inaugurate a new era in the scientific and practical reputation of the American people.

An institution of that kind cannot be a private enterprise, for in order to command the respect necessary to its existence and high purpose, it must be a public institution.

The writer has been educated at the Royal Technological Institute, Stockholm, where they have a complete set of workshops and laboratory, for the practical training of students between lecture hours. It is not expected, neither is it necessary that the student shall become an accomplished mechanic, but the object is to concentrate his mind on the work about which he is studying and calculating. When confined only to books and blackboards, his conceptions rarely extend any further. He acquires the knowledge by routine, as it were; the study becomes tedious to him, and when brought to bear on practice, the most simple problem may confound him. When a student is brought up in the combined science and practice, however, he generally acquires a taste for work—good workmanship and proper proportions, and the application of his science becomes a pleasure. He studies mathematics at the same time he learns drawing; physics and mechanics at the same time he makes his tools and models for machinery. His science is applied as fast as it is acquired, and he will never forget it. When a student is thus equipped for his journey of life, he is able to bring such physical laws into action as to secure success in all his enterprises. He will be able to record and report back to the institute his future experience, by which the most thorough connection may be kept up, between science and practice.

As things now stand, a man of most valuable information is not thus able to record his achievements; in fact, he may not know himself the very laws of his success; his experience and valuable knowledge die with him; his toiling successor will reiterate his blunders, and gain new experience by a new series of expensive trials and errors.

Steam-engineering and shipbuilding are arts in which we take the greatest pride; still there is no institution in the country where we learn to construct a steamer completely, or acquire the physical laws under which it operates. Shipbuilding and steam-engineering are yet considered different professions, while they are so intimately connected in steamboats that it would be impossible to trace a line of separation between them. The shipbuilder cannot properly construct a steamer without the knowledge of the machinery, neither can the engineer construct the machinery without a knowledge of the vessel; yet we rarely find one who can undertake both, and the result is a discord of action. They do not please one another, and neither of them takes that care in the whole arrangement which one controlling mind would do. In iron shipbuilding the two branches are more generally brought under one mind.

We rarely find a superintendent or proprietor in a machine-shop or shipyard, even in our navy yards, who can master an algebraical formula, or who is in possession of the rudiments of the science bearing on his profession. We have no school where we learn to make a proper working drawing, but students are taught to color drawings before they know how to construct a shadow; the surface of everything is learned, and the substance obscured. We never find a complete working drawing of a steamer when its building is commenced. In some cases, and even in the navy yards, *the drawing is made after the steamer is finished*, when an extra bill for alterations and experiments augments the originally intended cost to an unsatisfactory sum, and often results in a complicated arrangement of machinery, with donkies, fans, pumps, cocks, and pipes placed about the vessel, here and there, like scattered stumps and logs in a wood, and requires a more skilful engineer to keep it in order than the one who contrived it. In fact, ingenuity seems to surmount any obstacle that could possibly be encountered, for, in many cases, it shows no disposition whatever to prevent or avoid the difficulty by application of proper principles at the outset; but a machine, on the contrary, is invented by which to overcome the obstacle, and the aggregate contrivance denominated "practical."

In verification of this, we have many examples in the navy, but will here refer to a new iron steamer, built for the merchant service, whose machinery is one of those ingenious contrivances we frequently meet with; the slide valves alone, for only one cylinder, are operated by twenty connecting rods and forty journals, occupying a height of some thirty-five feet in the vessels, and even then the engine cannot be reversed without throwing the machinery out of gear, and reversing it by hand.

We must, in all ages and in all countries, expect active and operative minds to come forward with ingenious contrivances, sometimes with wild ideas, ridiculous in design, and wrong in mechanical principles; but then it is the function of science and knowledge to step in and correct their aberration, or, if necessary, to guard against or prevent their further introduction until developed to an educated design, which otherwise might lead to destruction of life and property.

On the other hand, most ingenious and valuable ideas are sometimes submitted to the opinion of scientific men with no practical knowledge, who may condemn them from an imperfect perception of their merit. It is only a knowledge of the combined theory and practice that can accomplish justice in all cases.

The great prospect now opening before us in the present new era of naval architecture, as connected with the new national navy yard (to be established at *League Island*, we hope), will necessarily, at some time, concentrate our serious attention upon the establishment of proper institutions, and a systematic corps of naval engineers; but when will this necessity become recognized, and the proper policy be pursued? Can it be accomplished by the efforts of conciliatory reasoning, or must it be forced upon us by the suffering and losses consequent upon engineering blunders, in which our present experience does not seem sufficient to bring us to the point?

The science of war has been taught by disasters, and has been gradually advanced by the force of proper institutions, and thorough discipline.

The navy has lately undergone a great and very important change, and converted into an entirely new school, by the introduction of steam and armored vessels, which change has already reduced considerably the number and length of the ropes in the old school. America has taken the lead in this new direction, and is the first nation on the globe which has brought the new naval school to the severest test, and demonstrated the necessity of a corresponding system of education. The old school is now proved to be incapable of conducting our new naval tactics.

In the army there has been no such sudden change, but the old school has been gradually improved to its present condition by the instrumentality of a properly organized corps of engineers, raised from the school-trenches to the highest accomplishment, and to the elevated rank which is due to their profession.

The works in the Departments of Ordnance, Fortification, and the Coast Survey, are of the highest order of science brought to a practical shape, unequalled in Europe.

Now let us ask, on the other hand, what, in like manner, the navy has done? Or what is to be expected from a department not educated in the lights and principles of the new school? The Naval Engineer Corps, which ought to be the soul of the Navy, is yet a mere tool to the old school, and destitute of proper organization, and with but a nominal discipline, for true discipline is out of the question where the superior officers are disciples of an obsolete school.

Our new naval warfare is an engineering operation which requires special education and a well-organized corps of engineers, with the distinguishing rank due to that office. The efficiency of the navy is at the mercy of the engineers, and cannot possibly be maintained without due respect to that body.

As it now stands the naval engineer, although in a restricted insignificant position, can manage and manipulate the old school to suit his own personal interest and convenience. He has none above him to fear. His superior officers must trust his words oracularly, of which we have plenty of examples in the navy. An engineer can argue that he has based his operation on physical laws discovered by himself, without being requested to explain such laws. Could that be so if education had done her proper work? or can we find such a case in the Departments of Ordnance, Fortification, or in the Coast Survey?

The country abounds in engineering talent, of which there is plenty in the navy, but it is very rarely much developed, and still less noticed. It would be surprising were it otherwise. The old naval school is not qualified to select or appreciate the engineer of ability; but, even if noticed, he is necessarily doomed to an insignificant rank and a discouraging career. We have the result now before us—the rebel pirate Alabama and others sweeping our vessels from the seas; the numerous blockade-runners can make regular trips in the midst of our boasting navy, on which we have spent hundreds of millions of dollars.

We admit that the naval operations are more difficult, and require manifold more science and talent than those of the army, but, in consequence, they require a corresponding culture in the officers in charge, to enable them to bring such physical laws into action, as are involved in the success. This can be attained only by adequate institutions for their education in the magnificent combination of our new naval school, which can only be properly estimated by being perfectly understood. Having now taken the lead of the world in naval warfare, and being unable to derive from foreign sources, either by precept or example, the means of giving a proper organization to the navy, we must follow up and avail ourselves of our own hard-earned experience for this purpose.

In our yet very feeble conception of the importance and of the *range* of knowledge in steam-engineering, it may be suggested that an apartment in the old Naval Academy, to be allotted to steam, would, perhaps, be sufficient for a school of engineers. But then let us reflect for a moment on the immense spectacle now before us, of our growing fleet of ironclads and colossal navy yards, entailing such an unbounded expense, and all of the great interest thus involved and confided with our national reputation to the hands of the engineers, and we must perceive that the latter must not only be equipped with proper knowledge, but must command all the respect and confidence which naturally attach to their important office. It is therefore necessary that a technological school, designed for the special purpose, should be instituted, of the highest possible order, and not limited only to scientific attainment, but foremost in the general *application of the sciences.*

We have numerous examples in Europe, particularly in Russia, where engineers are educated to only scientific attainments, and who, when they enter a machine-shop or engine-room, are incompetent for the proper conception of work, but are, nevertheless, intrusted with responsible stations where their practical achievements only lead to mischief.

Our experience throughout life teaches us that a practical man without science seldom makes such serious blunders as a scientific man without practice. The merit then of the *Techno-naval Academy* would be in the education of engineers in the practice, and not with mere scientific precepts of professors.

The writer has often observed the career of students from colleges, and regrets to say that too few of them turn their attention to work. Those who have received scientific education generally prefer to become professors, scientific advocates, patent agents, lawyers, philosophical secretaries, &c. &c., whilst the practical operation of our workshops suffer in the extreme. Every once in a while we have a steam-boiler explosion, killing off a great number of men, with great destruction of property; we build vessels which will not float; are often disappointed in the performance of vessels and machinery.; we waste great amounts of fuel, and we make extensive and costly experiments in steam-engineering without consulting the physical laws involved in the operation.

In iron foundries castings are often made with too little metal, and sometimes too much is wasted; the hydrostatic action of the fluid cast-iron in the mould is rarely understood; the law of shrinkage, strain, direction of crystallization, and sinking, in castings of irregular form, is not generally comprehended; and many other defects of experience exist which often cause the loss of valuable castings, for want of applied science. When the casting turns out a failure, it is generally said that the foundry superintendent is not skilful, or has not experience enough, which often means that he has not made blunders enough to secure success.

The general impression about the business of moulding and casting, as well as all other branches of mechanic arts, *is*, as has been repeatedly told to the writer, namely, that "the profession cannot be brought within the scope of science, but must be learned by experience alone."

On the other hand, scientific men without technical education, intrusted with practical problems, are generally not familiar with important circumstances involved in the operation, results in blunders; they are then derided as "scientific men."

The locomotive engineers do yet allow their thunderbolt to blow out smoke and fire to suffocate passengers, and set fire to houses and forests, when this nuisance of smoke and sparks could be so beneficially utilized in the work for which that fuel is intended.

The combustion of fuel and the utilization of heat, in our present locomotives, are a disgraceful and barbarous abuse of physical laws. The firebox in a locomotive dissolves many times the amount of fuel realized in work, and the heat there generated is so great that it is difficult to find materials for the firebox that are able to withstand it; whilst on the other end of the locomotive, there is applied an arrangement to create a vacuum by the exhaust steam from the cylinders, which, in fact, is only a cooling operation which puts the fire out when it enters the tubes, and the unconsumed carbon, in the form of smoke, with sparks of fire, is blown out through the chimney. The area of the fire-tubes in a locomotive is many times greater than that of the firebox, whilst the evaporative power of the firebox is many times greater than that of the tubes.

We are in possession of sciences, requisite for a more proper arrangement in a locomotive and in steam-boilers generally, by which not only all the carbon could be consumed, but also to utilize the heat in work, but we have not sufficient technical knowledge for their judicious application.

The writer has now gone very far in criticizing our standing as engineers, but hopes to be understood that his motive in so doing is a solicitude for the general interest. There are too many among us to boast of and exaggerate our numerous and real advantages over other nations, but apparently none to point out to us our deficiencies.

JOHN W. NYSTROM,
Engineer.

COMMUNICATION

TO THE

SECRETARY OF THE NAVY.

NAVY DEPARTMENT,
WASHINGTON, D. C., June 26, 1865.

SIR: On the 14th of this month I made an application to the Navy Department for orders to prepare, for the Naval Engineer Cadets, a "course of shipbuilding" based on the "parabolic principle," as explained in the printed papers accompanying the application.

On the 15th I received your communication stating that the proposition was declined.

This hasty refusal of the Department has encouraged me—with all deference—to renew the application in a more specific form, under conviction that I had probably failed to submit the subject in its true light; inasmuch as upon any other hypothesis, its intrinsic importance could scarcely have failed to have insured for it a different disposition. Indeed, I would deem it a neglect of duty on my part to drop a subject of such great moment, merely in consequence of a hasty and apparently inconsiderate reply of the Department, particularly as so many circumstances may have conspired, amidst a press of business, to prevent its receiving your Excellency's personal attention.

When it is considered not only that shipbuilding has not yet been developed to the condition of a true science, but that the country contains no school where even the empirical system under which the construction of vessels is now carried on, can be learned, we cannot expect our present naval constructors to dip into and approve a science which they do not understand, but distrust, and perhaps fear.

By means of long practice and experience, builders generally attain great skill and taste in the construction of ships, but, at the same time, they are yet ignorant of the physical laws and scientific principles which govern their success. Their skill and valuable knowledge die with them, and their toiling successors must reiterate the same blunders, and gain experience by the same renewed experiments and errors.

Such will not be the case when shipbuilding becomes really a science, for then we will be able to demonstrate, record, and perpetuate, through the unerring aid of mathematical formulas, a knowledge of the physical laws which relate to the subject, the accomplishment of which is now impossible, and the art itself kept by shipbuilders in profound mystery.

The indifference or hostility of shipbuilders to a scientific treatment of the subject, arises mainly from their conviction that it is impossible to bring their profession within the scope of science, and they persevere in regarding it as a mere craft. In verification of this, I can refer to numerous examples, of which the following is one:—

Last summer I made efforts to bring the "parabolic construction of ships" under the appreciation of Mr. John Lenthal, the Chief of the Bureau of Construction, which failed not only to secure his approval, but absolutely met with his disparagement. Mr. Lenthal was apprised that the "parabolic system" embodied a very simple method of recording the peculiarities of vessels, which would be of great importance; he refused, however, to credit the possibility of my plan, and gave me to understand (without looking at it) that he had all the records which could be necessary already, and that nothing more was wanted.

Soon after, I was set to work by Mr. Isherwood, the Chief of the Bureau of Steam-Engineering, to calculate from a great number of ships' drawings these very data, which were not, but which ought to have been calculated and recorded in the Bureau of Construction, and which data are of great importance in questions of steamship performance. In fact, the engineer cannot do well without them.

This proves conclusively that the naval constructor was in error regarding the perfection of his records.

There is not to my knowledge an engineer in the naval service who is competent to undertake such an investigation of the properties of ships as that made by me, although the subject belongs directly to his profession. The Corps of Naval Engineers should take the lead in all those progressive changes which naturally attach to their important office, and particularly in those changes which must eventually take place, namely, to combine the construction of machinery and vessels under one head.

Since the introduction into vessels of steam, and other mechanical contrivances which are daily increasing, the two branches have become so intimately connected, that it would be difficult to trace a line of separation between them. The engineer cannot construct the machinery without a knowledge of the vessel which is to contain it, and the shipbuilder cannot properly construct the vessel without consulting the engineer respecting the machinery, and we may expect what happened when the war broke out, namely, to build vessels wholly of iron, for which our present naval constructors are incompetent.

On account, therefore, of the profession of shipbuilding yet being in an empirical condition, and considered separate and apart from that of steam-engineering, there exists much jealousy between the two interests, which results in discord of action; neither of them taking that careful supervision over the whole arrangement which one controlling mind would do.

In many instances where government's vessels have been built in private establishments, the quality of workmanship has suffered considerably for this very reason, that the superintending naval engineer not being familiar with the construction of ships.

The failure of the light-draft monitors affords a still stronger proof of the necessity of instructing engineers in shipbuilding.

As matters now stand, ship constructors are generally so jealous of their profession, that the engineer can with difficulty obtain from them the necessary information to govern him in his own department; a jealousy which only indicates ignorance. For if their profession was brought to the rank of a true science, it could not be kept in a state of mystery, or as a matter of individual knowledge.

Now, believing that I have succeeded in developing shipbuilding to the condition of a true science, I desire to throw it wide open for the benefit of all, like the books of Euclid.

My system embodies the results of many years of labor, now in the form of raw materials, to be converted into tables and drawings for general use.

The details of the undertaking are too great for a single individual; operating alone, it would cost me several years to complete them, whilst with assistance from the Navy Department, it might be accomplished in a few months.

The great labor consists in calculating the tables, which will extend to some five thousand lines, the combination of which would comprehend the construction of an endless number of vessels.

The nature of the tables are very much like logarithms; they will equally suit any system of weights and measures, or any language and country, and will give the characteristic peculiarities of vessels at the first glance, such as the displacement; areas of water-lines and cross-sections; location of metacentre and centre of gravity, &c. &c.; and they will also give that most important item, so much sought for by scientific men and shipbuilders, namely, the *mean angle of resistance of vessels.*

The displacement of a vessel, bounded within a given *length*, *breadth*, and *depth*, can vary twenty-five per cent., for the same resistance, in moving through water; showing the immense importance of giving the vessel a proper shape.

Shipbuilders generally, through long practice, approach very near the proper shape or form of lines of vessels, but they also often transgress the sought-for limit which cannot possibly be determined by mere conjecture. But, by the "parabolic method," the most advantageous forms of lines are ascertained and calculated with the aid of tables, which can be used by constructors without a knowledge of mathematics.

For the accomplishment of the object here proposed, I would respectfully request your Excellency to select two or more young engineers, and place them at my disposition, for the purpose of assisting in the calculation of the tables, and of acquiring a thorough knowledge of the "parabolic construction of ships." This would be a very simple and easy course of introducing the science of shipbuilding into the Corps of Naval Engineers, and the Department will thus be placed in possession of scientific resources, which will forever place it out of reach of many errors, and of rash or ignorant experiments which have heretofore wasted so much of its means and its hopes alike unprofitably.

The mode of constructing ships, at the present day, is most generally accomplished by carving out a model from a piece of wood, by eyesight and conjecture—an operation which is often repeated several times before it happens to attain the desiderated end. In more advanced stages of the art, as in the navy, and in some few private establishments, drawings are made, from which models are also executed; but even then the lines are laid down repeatedly from conjecture, until sufficient approximation to the truth is believed to be attained. In both cases, the operation may be likened to the movements of a blind man walking by himself, whilst by the "parabolic method," the construction is started right at the outset, and thus an intelligent perception of principles and results reaches its conclusion with mathematical accuracy.

In the interest of science, as well as that of the Department over which your Excellency has so successfully presided, I earnestly request that my proposition may be considered with the attention which a subject of such importance deserves, and, in conclusion, would suggest, that whilst the government could lose nothing by granting my request, it would gain an advantage which, once possessed, it would never afterwards relinquish.

I have the honor to remain,
Your Excellency's ob't serv't,
JOHN W. NYSTROM,
Act. Chief Engineer, U. S. Navy.

Hon. Gideon Welles,
Secretary of the Navy.

MEMORANDUM.

NAVY DEPARTMENT,
WASHINGTON, D. C., July 8, 1865.

TO-DAY I called on Secretary Welles, about my application for assistance to calculate the tables for the "parabolic construction of ships," as expressed in the foregoing letter, when Mr. Welles said that he "could do nothing with it, as Mr. Isherwood does not approve your scheme, but says that there is no novelty in it." I then requested the Secretary to respond to my letter to that effect, which he ordered Assistant Secretary Fox to do, but no answer was received.

Assistant Secretary Fox told me that "this democratic government does not take the lead in matters of this kind, as monarchical governments do, but leaves them for the merchant or civil service."

I offered to show Captain Fox some samples of tables for the "parabolic shipbuilding," but he said he "would have no time to attend to it."

It is true the Navy Department has *not taken the lead* in any matter of progress, but left that for the civil service, but it has taken the lead and made extensive and costly experiments in the anti-expansion question of steam; in the building of vessels which will not float; in experimental researches in steam-engineering, extensively expatiated upon in large volumes of books, upon which I shall make no comments further than to state that the Navy Department has taken the lead in pointing out to the civil service where *not to follow.*

When the war broke out, the naval constructors were not competent to fulfil the requirements in the new era of naval architecture, and there was no naval engineer with requisite technical education to meet the emergency. The Chief of the Bureau of Construction, I understand, declined having anything to do with iron or armored vessels, and the projects for ironclads were necessarily intrusted to officers of the line, the result of which is well known, and not necessary to mention here, for the object of this writing is not to find fault, or to censure those who may have been inadvertently at fault, but to point out the necessity of taking proper steps to prevent similar occurrences in the future, and to prepare to follow up the progressive times.

In regard to the Chief Engineer Isherwood's saying that "there is no novelty in the parabolic system of shipbuilding," I am justified in taking prompt issue with him, for his scientific education does not extend so far as to enable him to judge whether there is novelty or not in the proposed method of constructing ships.

I have, however, good reason to believe, from specific indications in discussion with him, that Mr. Isherwood, in his own mind, really thinks that there *is* novelty in the "parabolic method." What then can constitute the object of the Chief in thwarting the interests and progress of the Corps of Naval Engineers?

ON THE

PARABOLIC CONSTRUCTION OF SHIPS,

AS SUBMITTED TO THE

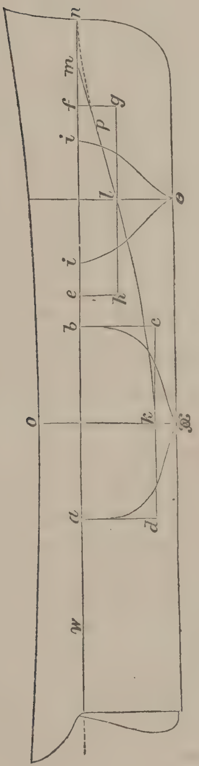
NAVY DEPARTMENT.

THE Parabolic System of constructing ships was originated by the celebrated Swedish naval architect, Chapman, about a century ago, at which period it was well received among shipbuilders, but on account of its then incomplete form (restricting conductors to particular shapes), it was gradually abrogated, until no trace could be found of it, even in works on shipbuilding. Mr. Chapman hit upon the fortunate idea that the cross-sections of the displacement of a vessel ought to follow a certain progression, in order to present the least possible resistance when moving through the water. He collected a great many drawings of ships of known good and bad performances, and made the following investigation. On each drawing he transformed the cross-sections of the displacement into rectangles of the same breadth as the greatest beam of the load-water-line of the vessel; placed their upper edges in the plan of the load-water-line, by which he found that the under edges of the rectangles formed a bottom, the curve of which were parabolas in ships of known good performances.

Let the accompanying figure, 1, represent a ship with the load-water-line, W, dead-flat cross-section $a \otimes b$, formed into the rectangle $a\,b\,c\,d$, and $i\,\theta\,i$ another cross-section formed into a rectangle $e\,f\,g\,h$, so that the breadth $e\,f$ is equal to $a\,b$; then the line $k\,l\,m$, Fig. 1, forming the bottom of the rectangles, should be a parabola with the vertex at k, and $k\,o$ the axis of the abscissa.

Mr. Chapman found that the parabola so obtained did not terminate at the stem n, but fell a little short at m. The deviation $m\,n$ was very small in vessels of his days, but in modern vessels it is more considerable, showing that there must be a point of inflection p in the curve. However erroneously we may set out in quest of an object, experience generally leads us towards correct scientific principles. In the case before us, experience has increased the deviation $m\,n$, and we know that inasmuch as nature admits of no physical by-laws, the curve cannot be a plain parabola. It is this increasing de-

Fig. 1.



viation *m n* which has led me to investigate the subject more carefully; starting on the principle that the resistance to a body in motion in a fluid, is a function of the square of the sine of the angle of incidence to the motion. Let *a b c d*,

Fig. 2.

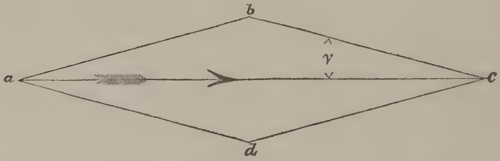
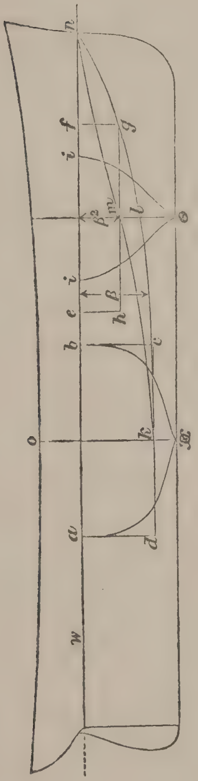


Fig. 2, be a body in motion in a fluid, in the direction *a c;* then the resistance to that body is found by experiments to be nearly as the square of the sine of the angle *v*, omitting friction.

From this it appears that the proper progression of the cross-sections should be as the square of the ordinates in a parabola.

Let Fig. 3 represent a vessel with the dead-flat 𝔛 and stem *n*. Draw the cross-section *a* 𝔛 *b* and the rectangle *a b c d*, as before described; draw a parabola *k l n* of any desired order, terminating at the stem; then the proper progression of the cross-sections should be as the square of the ordinates β. Let the depth $a\,d =$ 1, then the ordinates β will be fractions of *a d*, and the square β^2 multiplied by the area of the dead-flat cross-section 𝔛, would give the proper

Fig. 3.



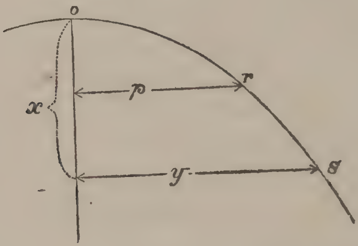
area of the ordinate cross-section θ, or $\theta = \mathbb{X} \beta^2$, Fig. 3. The line $k\,m\,n$ should then indicate the proper progression of the ordinate to cross-sections θ. The areas $efgh = i\theta i$.

The formula for a parabola in the conic section is—

$$y = \sqrt{2px}.$$

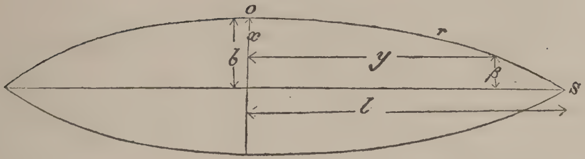
Referring to the accompanying figure, o is the vertex of the parabola, p = parameter, x = abscissa, and y = ordinate. Applying this formula and figure to the form of a ship, we place the vertex of the parabola at the dead-flat 𝔛, the axis of abscissa in the breadth b, and the largest ordinate y in the length, when the parabola $o\,v\,s$, Fig. 4, may represent a water-line in a vessel, as represented in Fig. 5.

Fig. 4.



The circle, ellipse, parabola, and hyperbola, in the conic sections are lines of the second order; but in the construction of ships we employ

Fig. 5.



these lines of any order whatever, for which we will denote the index of the root in the parabolic formula by the letter n.

The parameter p is the gauge for the parabola, but is inconvenient for our purpose; it will be better, therefore, to make a gauge that will consist of the given quantities, by limiting the parabolas within the size of the vessel when the limit $x = b$, half the breadth, and the limit $y = l$, half the length of the vessel.

The parabolic formulas will then appear—

$$y = \sqrt[n]{2\,p\,x}, \text{ or } l = \sqrt[n]{2\,p\,b}.$$

Of which—

$$p = \frac{y^n}{2\,x} = \frac{l^n}{2\,b}.$$

$$x = \frac{y^n}{2\,p} = \frac{y^n\,b}{l^n}$$

and—

$$y = \sqrt[n]{\frac{l^n\,x}{b}}.$$

In these formulas the parabola is gauged by the half-length l, and half-breadth b.

Let β denote the distance from the centre line of a vessel to the water-line, then $\beta = b - x$, or $x = b - \beta$, which, inserted in the above formulas, will give—

$$x = b - \beta = \frac{y^n b}{l^n},$$

of which—

$$\beta = b - \frac{y^n b}{l^n} = b\left(1 - \frac{y^n}{l^n}\right).$$

Let the depth $a\,d$, figs. 1 and 3, $= b$, represent the area of the dead-flat cross-section $\mathfrak{X}$, then the ordinate cross-sections will be—

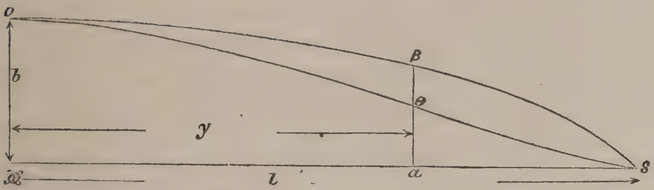
$$\beta = b\left(1 - \frac{y^n}{l^n}\right) \quad . \quad . \quad 1$$

$$\beta = b\left(-1 - \frac{y^n}{l^n}\right)^2 \quad . \quad . \quad 2$$

The formula 1 gives the plain parabolas $k\,l\,m$, fig. 1; or $k\,l\,n$, fig. 3; or $o\,\beta\,s$, fig. 6; whilst the formula 2 gives the paracyma $k\,m\,n$, fig. 3, or $o\,\theta\,s$, fig. 6.

Formula 1 gives nearly the form of ships as constructed in the days of Chapman, whilst formula 2 gives the form of modern ships, constructed for speed.

Fig. 6.

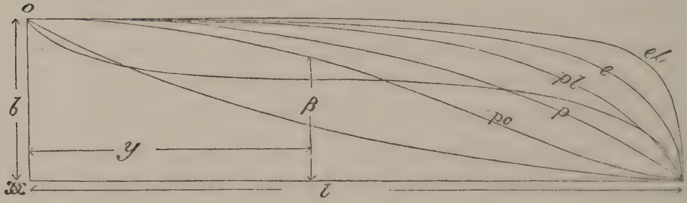


I have investigated the progression of the cross-sections in a great many vessels, from most parts of the world, as will hereafter be shown in a treatise on the parabolic construction of ships now in progress. Many American vessels agree perfectly with formula 2, of which the U. S. frigate *Niagara*, constructed by the late Mr. Steers, is one. The formula 1, which embodies Chapman's method, is therefore not applicable in modern shipbuilding, which I think is the reason why the original parabolic system has not been more generally adopted. It is not always necessary to pay the greatest attention to speed, as there are many other conditions of greater importance, namely, freight, shallow draught, location of metacentre, and centre of gravity of the vessel, for which it becomes necessary so to arrange the parabolic construction of ships, that it will accommodate itself to all the requirements, as well as to the taste of the shipbuilder. This can be accomplished by raising the ordinate β to any arbitrary power, which we will designate with the letter q, and call it the power of the exponent n, when the final formula will appear—

$$\beta = b\left(1 - \frac{y^n}{l^n}\right)^q \qquad . \quad . \quad 3$$

This is the general formula for the parabolic construction. Simple as it is, it gives any line or form of a ship that can reasonably be required. It will form a square, rectangle, triangle, circle, ellipse, parabola, hyperbola, cyma; all of any order or combination.

Fig. 7.



b = half the breadth, or area of dead-flat 𝔛.

l = length from 𝔛 to the stem or stern, or depth under water-line.

For the frames, the depth d, from load water-line to the keel, takes the place of l.

β = ordinate for the line, or ordinate cross-section.

y = abscissa.

n = exponent.

q = power of the exponent n.

The variety of lines represented by fig. 7 are obtained by altering the power q, while n remains constant; or any variety of lines can be obtained for each value of the exponent n.

It is here found necessary to the development of the subject, to propose or establish new names to such lines as have not heretofore been defined or subjected to an algebraic formula. The degree of development of an art may be correctly measured by the perfection of its vocabulary. As the construction of ships has not heretofore been brought to a perfect system, we have not been able to define the great variety of lines or forms of ships. We can say a vessel is very sharp, or very full, with more or less rise of floor; but have no language by which to convey correctly, how sharp, how full, or with how much rise of floor. As an illustration it may be mentioned, that on one occasion I met some shipbuilders, and discussed with them the construction of ships, when one said, "I am constructing a ship that will be so sharp, that you cannot roll a barrel on the lower deck, within fifteen feet of the bow," which made me no wiser. Now, in the language of the parabolic construction, to convey the same idea with precision and accuracy, we have only to give the exponent and power, which not only impress the mind clearly with the correct degree of sharpness, but also with the complete form of the vessel.

We have both in Europe and America many curiously constructed vessels, and some of them reported to perform wonderfully, but we have not been able to record their peculiarities; for even the drawing of their lines would fail to convey with correctness what constitutes their novelty or folly.

It is therefore proposed to establish the following technical terms in naval architecture:—

Any line $p\ l$, in the accompanying figure, 7, located between the parabola p and ellipse e, is to be called *Paralipse.*

Any line $p\ c$, located under or within the parabola p, to be called *Paracyma.* In architecture, cymas are generally constructed of circle-arcs, but in this case cymas are derived from parabolas.

Any line $e\ l$, extending outside of the ellipse, to be called *Evolipse.*

In modern constructed vessels, those lines are generally distributed as follows:—

All water-lines of the displacement are *Paracymas*, with the highest power near the keel, approaching parabolas near the load water-line, which latter may also be a *Paracyma*. The frames are generally *Paralipses* about the middle of the vessel, and terminate in *Parabolas* and *Paracymas*, in the stern and bow. Above the water, the horizontal lines are generally *Parabolas* in the foreship; and in the aftership, *Paralipses*, *Ellipses*, and *Evolipses*.

The power q defines the line as follow:—

Parabola p, $\beta = b\left(1 - \frac{y^n}{l^n}\right)^{q = 1.}$

Ellipse e, $\beta = b\left(1 - \frac{y^n}{l^n}\right)^{q = \frac{1}{n}.}$

Circle, $\beta = \mathrm{R}\left(1 - \frac{y^n}{\mathrm{R}^n}\right)^{q = \frac{1}{n}.}$

Paracyma $p\,c$, $\beta = b\left(1 - \frac{y^n}{l^n}\right)^{q > 1.}$

Paralipse $p\,l$, $\beta = b\left(1 - \frac{y^n}{l^n}\right)^{q \text{ between 1 and } \frac{1}{n}.}$

Evolipse $e\,l$, $\beta = b\left(1 - \frac{y^n}{l^n}\right)^{q < \frac{1}{n}.}$

In my treatise on the parabolic construction of ships, now in progress, there will be calculated 54 values of the power q, each with 90 different exponents n, making 4860 different lines, which will cover the most general requirements in practice. Samples are here given.

SAMPLE TABLE FROM FORMULA 1.

Exp. *n*.	1	2	3	4	5	6	7	a′∞′D′	*e′*	*m′*	*t′*
1	.1250	.2500	.3750	.5000	.6250	.7500	.8750	.5000	.3333	.	
1.25	.1337	.3020	.4443	.5795	.7065	.8232	.9257	.5555	.3461	.	.
1.5	.1815	.3505	.5059	.6464	.7704	.8750	.9558	.6000	3571	.	
1.75	.2084	.3955	.5607	.7027	.8203	.9116	.9737	.6363	.3666	.	
2	.2344	.4375	.6094	.7500	.8594	.9375	.9844	.6666	.3750	.3021	1.333
2.25	.2595	.4765	.6527	.7898	.8899	.9558	.9907	.6923	.3823	.3288	1.447
2 5	.2838	.5129	.6912	.8232	.9149	.9687	.9945	.7142	.3888	.3502	1.562
2.75	.3073	.5466	.7254	.8513	.9326	.9779	.9967	.7333	.3948	.3688	1.682
3	.3390	.5781	.7558	.8750	.9476	.9844	9988	.7500	.4000	.3857	1.800
3.25	.3521	.6074	.7829	.8949	.9587	.9889	.9988	.7647	.4047	.4010	1.922
3.5	.3733	.6346	.8070	.9116	.9677	.9922	.9993	.7777	.4091	.4144	2.040
3.75	.3939	6600	.8284	.9256	.9747	.9945	.9996	.7894	.4130	.4263	2.160
4	.4138	.6836	.8474	.9375	.9802	.9961	.9998	.8000	.4166	.4376	2.285
4.5	.4517	.7260	.8794	9559	.8979	.9980	.9999	.8181	.4230	.4570	2.534
5	.4871	.7627	.9046	.9687	.9926	.9990	.9999	.8333	.4286	.4734	2.775
6	.5512	.8220	.9404	.9844	.9972	.9997	1.000	.8571	.4375	.5000	3.270
7	.6073	.8665	.9627	.9922	.9989	.9999	1.000	.8750	.4444	.5202	3.770
8	.6564	.8999	.9767	.9961	.9996	.9999	1.000	.8888	.4500	.5354	4.272
12	.7986	.9683	.9964	.9997	.9999	1.000	1.000	.9231	.4643	.5768	6.275
16	.8819	.9900	.9994	.9998	.9999	1.000	1.000	.9412	.4720	.6060	8.273

SAMPLE TABLE FROM FORMULA 2.

Exp. *n*.	1	2	3	4	5	6	7	a′∞′D′	*e′*	*m′*	*t′*
1	:1563	:6250	.1406	.2500	.3906	.5625	.7656	.3333	.2500	.	
1.25	:2363	:9123	.1974	.3359	.4992	.6777	.8569	.3968	.2691	.	
1.5	:3295	.1128	.2547	.4179	.5934	.7656	.9136	.4500	.2860	.	
1.75	:4342	.1565	.3144	.4938	.6729	.8310	.9481	.4949	.3000	.	
2	:5493	.1914	.3713	.5625	.7385	.8789	.9690	.5333	.3125	.2273	1.219
2.25	:6735	.2271	.4260	.6237	.7920	.9136	.9815	.5664	3189	.2541	1.273
2.5	:8056	.2630	.4777	.6777	.8371	.9385	.9890	.5952	.3333	.2770	1.335
2.75	:9445	.2988	.5262	.7248	.8698	.9563	.9934	.6205	.2973	.2979	1.402
3	.1090	.3342	.5713	.7656	.8980	.9690	.9961	.6428	.3164	.3164	1.472
3.25	.1240	.3689	.6130	.8008	.9192	.9779	.9977	.6627	.3571	.3255	1.545
3 5	.1394	.4028	.6512	.8310	.9365	.9844	.9986	.6805	.3636	.3500	1.620
3 75	.1555	.4356	.6862	.8569	.9501	.9890	.9992	.6966	.3695	.3638	1.697
4	.1712	.4673	.7181	.8789	.9608	.9922	.9995	.7111	.3750	.3765	1.773
4.5	.2045	.5270	.7733	.9137	.9759	.9961	.9998	.7363	.3846	.4000	1.929
5	.2373	.5804	.8184	.9385	.9852	.9980	.9999	.7576	.3929	.4196	2.088
6	.3038	.6729	.8843	.9690	.9945	.9995	.9999	.7912	.4062	.4517	2.407
7	.3688	.7508	.9269	.9844	.9979	.9999	1.000	.8166	.4166	.4768	2.732
8	.4308	.8098	.9540	.9922	.9992	.9999	1.000	.8366	.4250	.4962	3 060
12	.6377	.9379	9929	.9995	.9999	1.000	1.000	.8861	.4464	.5463	4.390
16	.7778	.9800	.9989	.9999	1.000	1.000	1.000	.9129	.4629	.5763	5.715

The length l from the dead-flat 𝔛 to stem or stern, also the draft of water from the load line to the base-line, are each divided into eight parts, forming the ordinates 1, 2, 3, 4, 5, 6, 7, in the table, counted from the stern or stem to the centre 𝔛, or from base-line to water-line, as represented in the accompanying plate.

Either table, exponent, or power, can be employed for either frames, water-lines, or displacement.

$$\left.\begin{array}{l}\text{Area of any water-line } \mathbf{a} \text{ or } a.\\ \text{`` \quad `` \quad cross-section } \mathfrak{X} \text{ or } \theta.\\ \text{Cubic contents of displacement D.}\end{array}\right\}=\int \beta\, dy,$$

which integral coefficient is contained in the column **a** 𝔛 D.

The depth of the centre of gravity of any cross-section, or of the displacement, or the distance from the dead-flat 𝔛, to the centre of gravity of the area of any water-line, or of the fore or aft part of the displacement, will be—

$$e=\int\frac{\beta\, y\, dy}{\mathbf{a},\ \mathfrak{X},\ \text{or D}},$$

which integral coefficient is contained in the column e.

The height of metacentre will be—

$$m=\frac{2}{3\text{D}}\int \beta^3\, dy,$$

which integral coefficient—

$$m' = \frac{2}{3}\int \beta^3\, dy,$$

is contained in the column m'.

When the power q and exponent n are given, we have—

Height of metacentre $m = \dfrac{l\, b^3\, m'}{\mathrm{D}}$.

Momentum of stability $= \mathrm{Q} \sin. v \left(\dfrac{l b^3 m'}{\mathrm{D}} \pm g\right)$.

Q = weight of the vessel, and g = vertical height between the two centres of gravity.

The mean angle of resistance of the vessel through water is found by the following formula:—

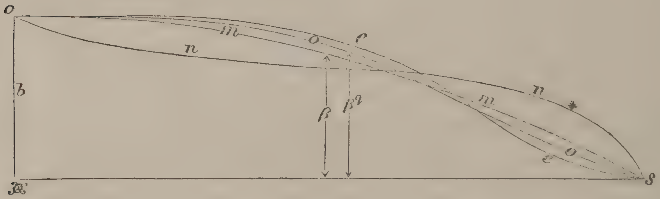
$$tang.\, v = q^2\, b\, n^2 \int \left(1 - \frac{y^n}{l^n}\right)^{2q-2} \frac{y^{2n-2}}{l^{2n}}\, dy.$$

The integral coefficient of this formula is contained in the last column t' in the table.

It does not appear that Chapman attempted to form the water-lines and frames of a vessel by the parabolic method. He says the area of the cross-sections can be approximated by a parabola, placing the vertex at the keel; but this cannot give a proper shape to the frame. Inasmuch as the displacement of a vessel is the integral of the areas of the water-lines and cross sections, and as those areas are integrals of the ordinates in the frames and water-lines, they are all convertible into one another by a common formula, which is the formula 3, and which formula embodies Chapman's system completely; simply by placing $q = 1$. But, by so doing, the constructor is restricted to a stiff and obstinate guide, which will not yield to his taste, and we have the result before us; namely, the shipbuilder assumes his independence. It would be futile to attempt to introduce a system of constructing ships that would not accommodate itself to the taste of the constructor. By Chapman's system, when the length, breadth, depth, and the displacement are given, then the sharpness of the vessel is obdurately fixed; while by giving an arbitrary value (as here proposed) to q, the sharpness and ease of the lines can be made to vary considerably, and accommodate themselves to the taste of the architect.

Suppose the area, length, and breadth of the load-water-line of a vessel are given, which is substantially the same as if the displacement, dead-flat, cross-section, and length were given; then Chapman's method, formula 1, will produce the fixed line, say *o m m s*, fig. 8, while the formula 2 will produce any variety of lines, as *o o o s*, or *o e e s*, or if we wish to go to the extreme the wrong way, we can produce the line *o n n s*; in fact, the formula 3 can manipulate the displacement the same as one can work a lump of soft clay in his hands. This is a property of my parabolic system which does not yet appear to have been appreciated, but whose utility, when once fairly understood, must be universally accepted.

Fig. 8.



It is not to be supposed that this short outline of the parabolic construction embodies the full capacity of that method, for which a much more complete work would be required. When constructors become accustomed to the tables, they can readily select the proper exponents, and reason intelligibly with each other on the forms of lines and vessels.

APPLICATION

Let it be required to construct a vessel of the following dimensions:—

Length in the load-line, $L = 325$ feet.
Breadth of beam, $B = 40$ "
Draft of water from base-line, $d = 18$ "

Let the dead-flat cross-section be selected from table 1, of the exponent $n = 6$; then the numbers in the line 6, multiplied by half the beam $b = 20$ feet, will give the corresponding ordinates in the dead-flat frame; and the area will be $\mathfrak{X} = B\,d\,\mathfrak{X}' = 40 \times 18 \times 0.8571 = 617.112$ square feet.

Let the load-water-line be selected from table 2, of exponent $n = 3$; then the numbers in the line 3, multiplied by half the beam $b = 20$ feet, gives the corresponding ordinates in the water-line; and the area will be $\mathbf{a} = L\,B\,\mathbf{a}' = 325 \times 40 \times 0.6428 = 8356.4$ square feet.

Let the displacement be selected from table 2, and of exponent $n = 3.25$, then the numbers in the line 3.25, multiplied by the dead-flat cross-section $\mathfrak{X} = 617.112$ square feet, will give the corresponding ordinate cross-sections of the displacement. The cubic contents of the displacement will be $\mathrm{D} = \mathfrak{X}\,\mathrm{L}\,\mathrm{D}' = 617.112 \times 325 \times 0.6627 = 132912$ cubic feet, or 3797.4 tons.

The sample tables here given do not extend so far as to allow a correct calculation of the depth of the centre of gravity of the displacement, but suppose the areas of the water-lines to progress with the exponent $n = 5$, table 1, then the depth of the centre of gravity of the displacement will be $d\,e' = 18 \times 0.4286 = 7.7148$ feet.

The height of metacentre above the centre of gravity of the displacement will be—

$$m = \frac{\mathrm{L}\,b^3\,m'}{\mathrm{D}} = \frac{325 \times 20^3 \times 0.3164}{132912} = 6.1898 \text{ feet.}$$

This metacentre is very low, on account of having assumed a very sharp water-line.

The tangent for the mean angle of resistance will be—

$$tang.\,v = \frac{\mathfrak{X}\,t'}{\mathrm{L}\,d} = \frac{617.112 \times 1.472}{\frac{1}{2} \times 325 \times 18} = 0.31056$$
$$= tang.\,11^\circ\,33'.$$

The actual resistance by impact and friction, the wet area of the hull of the displacement, &c. &c., are calculated by simple formulas not given in this short outline of the parabolic construction.

Recording Formula.

The form of any vessel may be recorded by one general formula, as follows:—

$$\left.\begin{matrix}\mathrm{W}\,n\,q\\ \mathrm{D}\,n\,q\end{matrix}\right\}\, l \begin{pmatrix}\mathrm{L}\,b\,d\\ \otimes\,n\,q\end{pmatrix} l \left\{\begin{matrix}n\,q.\\ n\,q.\end{matrix}\right.$$

The first factor $\left.\begin{matrix}\mathrm{W}\,n\,q\\ \mathrm{D}\,n\,q\end{matrix}\right\} l$ represents the properties of the after-body of the displacement. $\mathrm{W}\,n\,q$ represents the exponent n and power q of the load-water-line; $\mathrm{D}\,n\,q$ the exponent n and power q of the displacement, and l the length from the stern-post to the dead-flat $\otimes$ in a fraction of the whole length L of the vessel.

The second factor $\begin{pmatrix}\mathrm{L}\,b\,d\\ \otimes\,n\,q\end{pmatrix}$ represents the dead-flat, or L the whole length of the vessel, b the half dead-flat breadth in the load-water-line, and d the draft of water from the base-line to the load-water-line. $\otimes\,n\,q$ represents the exponent n and power q of the dead-flat $\otimes$.

The third factor $l \left\{\begin{matrix}n\,q.\\ n\,q.\end{matrix}\right.$ represents the properties of the fore-body of the displacement; l is the length from the dead-flat $\otimes$ to the stem of the vessel; n and q represent the exponents n and powers q for the load-water-line and the displacement respectively; l and l may be expressed in real length, as feet.

A well-proportioned sailing yacht may be set up as follows, with numerical values in the general formula:—

$$\left.\begin{matrix}\text{W}\ 3\times2\\ \text{D}\ 2\times2\end{matrix}\right\}\ 0.381\ \begin{pmatrix}80\times8\times8\\ \mathfrak{X}\ 3\times4\end{pmatrix}\ 0.619\ \left\{\begin{matrix}2.75\times2.\\ 2\times2.\end{matrix}\right.$$

These data will enable a shipbuilder to construct a sailing yacht of definite shape.

When constructors become accustomed to the parabolic method, they can determine with great correctness the exponent n and power q of any line at first sight, and thus enable them to record, by the above formula, the form of any vessel exposed to view, from which a similar vessel can afterwards be constructed.

Records of this kind have been frequently made in shipyards by the author, of which a case may be mentioned, namely, the "Dictator" (built by Hogan & Delamater, New York), of which the following formula was recorded:—

Formula for the Dictator.

$$\left.\begin{matrix}\text{W}\ 5.5\times1.75\\ \text{D}\ 4.75\times3.25\end{matrix}\right\}\ 96\ \begin{pmatrix}240\times21\times16\\ \mathfrak{X}\ 2.75\times0.5\end{pmatrix}\ 144\ \left\{\begin{matrix}2.75\times1.5.\\ 3\times2.\end{matrix}\right.$$

From these data can, at any time, be constructed a vessel similar to the "Dictator," by any one familiar with the method. The draft 16 feet is from the base-line to the under side of guards, but she draws some four feet more water.

A skilful shipbuilder may, by his empirical mode of reasoning, be able to memorize, for a short time, the form of a ship, but most likely in a clouded condition, which will soon clear away.

Recording Tables.

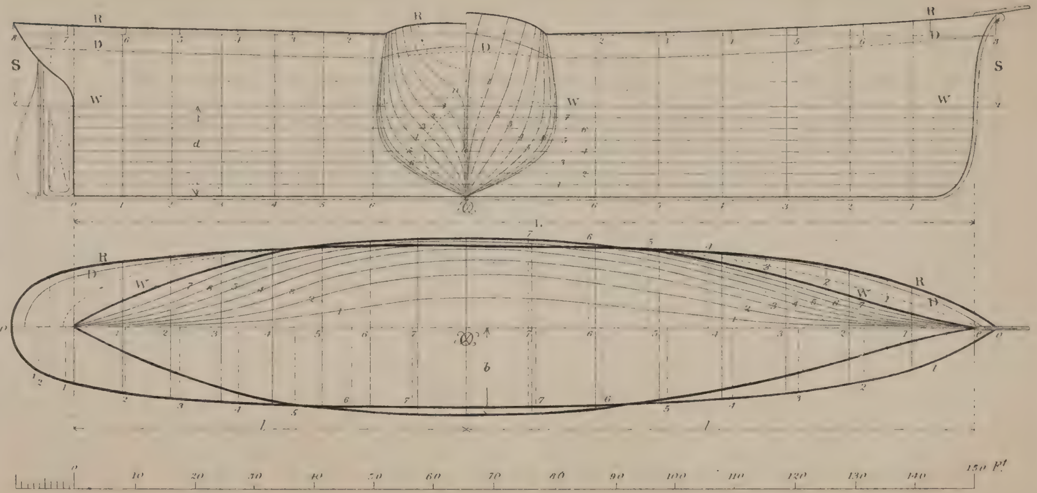
The properties of a vessel can be more minutely and fully recorded in a table of a general form, as follows. The vessel being divided from the dead-flat ⊗ to the stern and to the stem, also from the base-line to the load-water-line, into eight equal parts, as shown on the accompanying plate:—construct the following two tables, one for the after-ship and one for the fore-ship. The data given in these tables are for a steamboat. The top line S contains the sheer of the vessel, or height from the load-water-line to the rail, at each division or ordinate. The line R contains the ordinates for the rail, and D that of the deck. In these tables, the dimensions do not correspond with those on the plate. The line D *w* means a line of a plane tangenting the deck at ⊗, and parallel to the load-water-line; the deck-line was not shown on the drawing from which this table is made. The line *Ord.* contains the number of each ordinate from stem or stern to the dead-flat 𝔛. The line W contains the ordinates for the load-water-line, and the lines 7, 6, &c. &c., contain the ordinates for the corresponding water-lines.

The line o contains the half-width of throat in the base-line. The line θ contains the half-areas of the ordinate cross-sections of the displacement. The line n contains the exponent for the frames. The line q contains the powers of the frames. The line u contains the length of each frame from the base-line to the load-water line.

The column **a** contains the area of each water-line, n the exponent, and q the power for the corresponding water-line. Column o contains the half-width of throat on the stern-post or stem; in this case it shows that the boat is a propeller, because the throat is widest at the ordinate 4, where the propeller shaft goes through the stern-post. Columns A or F contain the ordinates for the throat on stern-post or stem, measured from the perpendicular. Column u contains the length of the corresponding water-line from stem or stern to the dead-flat 𝔛.

The corner θ 𝔛 contains the half-area of the greatest immersed cross-section, which, in this case, is 133.4 square feet. Corner θ **a** contains

Nystrom's Parabolic Construction of Ships.



the half-displacement of the vessel from 𝔛 to stem 10000, or stern 8528 cubic feet. The corners $\theta\, n$ and $\theta\, q$ contain the exponent and power of the displacement longitudinally; and the corners $\mathbf{a}\, n$ and $\mathbf{a}\, q$ contain the exponent and power of the displacement vertically. The corner $q\, q$ contains the mean angle of resistance 13° 54′, or mean angle of delivery 14° 49′. The corner $u\, u$ contains the wet surface of half the displacement from 𝔛 to stern or stem. The constructing draft of water and length are contained in the corners $o\, u$ and $u\, o$.

This form of table will suit for any shape or size of vessel. It is like a tailor's measurement of a coat. When the shipbuilder becomes accustomed to it, he can see, at the first glance, the properties of the vessel.

When thus brought to a system, forms of tables could be printed and bound in a book, for the use of shipbuilders.

The general formula for this steamboat is—

$$\left.\begin{matrix}\text{W} & 3.375 \times 0.824 \\ \text{D} & 3.375 \times 1.375\end{matrix}\right\} 88.6 \left(\begin{matrix}188\;6 \times 15.35 \times 10 \\ \mathfrak{X}\, 6.75 \times 1.125\end{matrix}\right) 100 \left\{\begin{matrix}4.5 \times 1.25. \\ 3.625 \times 1.375.\end{matrix}\right.$$

When the shape of the vessel is thus obtained and recorded, divide the frames as required in building the ship.

The formula for the steam-propeller represented on the plate is—

$$\left.\begin{matrix}\text{W} & 2.5 \times 1 \\ \text{D} & 2 \times 2\end{matrix}\right\} 65.625 \left(\begin{matrix}150 \times 15 \times 15 \\ \mathfrak{X}\, 3 \times 1\end{matrix}\right) 84.375 \left\{\begin{matrix}2 \times 1.18. \\ 2 \times 2.\end{matrix}\right.$$

Records of a Steamboat.—After-Ship.

S	11.60	10.90	10.30	9.83	9.50	9.40	9.32	9.25	9.20					
R	0.00	11.22	12.34	12.98	13.50	13.95	14.20	14.35	14.40				15.00	109.6
D w	0	6.95	11.20	13.11	14.05	14.72	14.90	15.06	15.15				8.88	101.6
Ord.	0	1	2	3	4	5	6	7	𝔛	**a**	n	q	A	u
W	0.50	6.30	10.30	12.70	14.10	14.90	15.15	15.30	15.35	1084	3.375	0.824	0.00	91.62
7	0.50	5.20	9.26	12.18	13.90	14 88	15.14	15.28	15.34	1040	3.6	1.12	0.80	91.40
6	0.60	4.33	8.30	11.52	13.63	14.75	15.11	15.28	15.32	1000	3.5	1.3	1.27	91.00
5	0.78	3.63	7.35	10.80	13.21	14.58	15.08	15.25	15.30	976	3.25	1.375	1.35	90.75
4	0.85	3.12	6.55	9.90	12.60	14.23	14.89	15.12	15.22	935	3	1.4	1.41	90.00
3	0.80	2.54	5.62	8.80	11.60	13.50	14.42	14.60	14.91	884	2.75	1.5	1.48	89.55
2	0.60	1.95	4.51	7.40	10.09	12.20	13.20	13.60	13.90	772	2.575	1.75	1.50	89.15
1	0.50	1.20	2.90	4.90	6.45	7.50	8 10	8.35	8.50	.507	2.68	1.625	1.50	88.91
0	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50				8.61	88.60
θ	0.00	31.50	63.70	92.00	114.7	123.9	129.3	131.0	133.4	8528	3.375	1.375		811.0
n		.5625	.9375	1.187	1.800	4.250	6.25	6.50	6.75	1.687				90.14
q		0 611	0.375	0.422	0.368	0.808	1.125	1.125	1.125	0.398		14°49′		
u	10.00	12.13	15.00	17.20	19.30	20.85	21.70	21.62	22.30	160.57	17.84		1607.5 sq. ft.	

From W to D w, 4 feet. From D to R, 3.5 feet.

Records of a Steamboat.—Fore-Ship.

S	12.50	11.74	11.15	10.65	10.20	9.87	9.66	9.35	9.20					
R	1.40	10.16	12.68	14.44	14.59	14.50	14.50	14.49	14.40				−1.20	105.4
D w		6.75	11.35	13.78	14.80	15.02	15.07	15.10	15.15				−0.1	103.0
Ord.	0	1	2	3	4	5	6	7	⊗	a	n	q	F	u
W	0.50	5.60	10.25	13.10	14.50	15.20	15.27	15.30	15.35	1218	4.5	1.25	1.25	102.8
7	0.50	5.14	9.90	12.87	14.33	15.16	15.25	15.29	15.34	1200	4.5	1.375	1.75	102.8
6	0.50	4.72	9.46	12.55	14.14	15.08	15.22	15.28	15.32	1184	4.25	1.375	2.25	102.9
5	0.50	4.25	8.83	12.04	13.81	14.92	15.16	15.25	15.30	1156	3.875	1.375	3.00	103.0
4	0.50	3.75	8.09	11.35	13.31	14.62	14.90	15.12	15.22	1102	3.56	1.50	4.00	102.6
3	0.50	2.97	7.12	10.30	12.50	14.11	14.40	14.60	14.91	1053	3.25	1.50	5.15	101.2
2	0.50	2.00	5.73	8.50	10.95	12.70	13.19	13.60	13.90	925.5	2.875	1.625	6.80	100 9
1	0.50	0.75	3.30	4.80	7.30	7.50	8.00	8.35	8.50	572.5	3.125	1.75	9.15	100.3
0	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50				17.00	100.0
θ		34.8	72.15	98.2	119.1	125.5	129.3	131.2	133.4	10000	3.625	1.375		9165
n		1.35	1.875	2.72	2.75	4.75	5.5	6.5	6.75	1.5				101.8
q		0.75	0.766	0.845	9.33	1.00	1.00	1.125	1.125	0.222		13°54′		
u	10.00	11.00	15.45	18.20	20.15	21.40	21.80	22.00	22.30	162.30	18.03		18354 sq. ft.	

The general shipbuilding tables from formula 3, have been calculated, corrected, and rearranged several times. The undertaking is similar to that of calculating tables of logarithms, and although equally extensive, is much more complicated, and too great a task for a single individual. The immense amount of labor which has been spent on logarithms by different mathematicians, in different countries, is well known, as also that it required some two centuries before they were brought to a condition of thorough reliability.

Baron Napier invented the foundation of logarithms printed in his *Canon Mirabilis Logarithmorum*, in the year 1614, but started on an inconvenient basis, which was improved by Professor Henry Briggs in 1615, who calculated our present common logarithms for the natural numbers up to 30,000, and in 1628, the logarithms for all natural numbers were computed for the first time up to 100,000. Since then the logarithms have been calculated over and over again by different mathematicians, who have continually discovered errors in the same, until very recently the last edition of Vega's tables has been generally accepted as correct.

The shipbuilding tables may be considered in a similar situation.

The difficulty is first to calculate a complete and well-arranged set of tables, then to have them perfectly corrected and purged from errors; all of which could have been accomplished in the Bureau of Steam-Engineering, had I only succeeded in securing for them the appreciation of the Navy Department.

The individual sacrifice of labor and time necessary to perfect these tables is altogether inconceivable by the uninitiated, and would never be compensated by the immediate sales of such a publication. I, therefore, amidst my multifarious and pressing engagements, leave to others both the profit and distinction that may accrue from their ultimate perfection, and will cheerfully contribute my quota as a purchaser, to their cost, rather than assume this herculean labor myself.

Constructor's Office, U. S. Navy Yard,
Philadelphia, Sept. 14, 1865.

Sir: I have examined your proposed method of constructing ships, called the parabolic construction, and am of the opinion it will be very useful for the shipbuilding profession, and think it embraces, in full, the merit therein described.

I am, very respectfully,
Your obedient servant,
W. L. HANSCOM,
Naval Constructor.

J. W. Nystrom,
Civil Engineer,
Philadelphia.

PHILADELPHIA, Sept. 14, 1865.

SIR: Having been shown the system proposed by you for calculating the data necessary in the construction of the models of vessels, I am of the opinion that so certain and easy a mode of ascertaining the shape and dimensions, hitherto assumed by individual judgment, would be immensely valuable to the profession.

And with regard to the principle on which said system is based, I have no reason, from my present knowledge of it, to doubt that by its adoption, at least a great improvement in models over the average now made would result.

Very respectfully,
J. VAUGHAN MERRICK.

J. W. NYSTROM, ESQ.

RESIGNATION.

Navy Department,
Washington, D. C., July 8, 1865.

Sir: I respectfully beg leave to tender my resignation as Acting Chief Engineer in the U. S. Navy.

At the time the Navy Department paid me the compliment of declining a previous resignation, tendered on the 3d of February last, I gave as reason that "the pay was much less than I could obtain in private employment, whilst the living was much higher in Washington."

However true this may have been, the real reason for tendering my resignation, both then and now, as stated to Mr. Isherwood, the Chief of the Bureau of Steam-Engineering, was that I have failed in bringing my attainments and qualifications to the notice and due appreciation of the Department.

My present duties are limited, I may say, to questions of simple arithmetic, which could be performed by a schoolboy, whilst my engineering knowledge, which is actually needed, and could be advantageously employed for the benefit of the navy and the country, is thrown away.

Under a conviction that my knowledge of naval engineering would render me eminently useful, and that from the present condition of the country the Department actually requires the utilization of every possible means which could be directed to the advancement of this paramount interest, I cannot conscientiously continue on the pay-rolls of the navy whilst the class of services I am required to render are at once so unworthy of myself, and so inadequate a requital to the government for the emolument which it so generously confers upon me.

I have the honor to remain,
Your Excellency's ob't serv't,
JOHN W. NYSTROM,
Act. Chief Engineer, U. S. N.

Hon. GIDEON WELLES,
Secretary of the Navy.

MEMORANDUM.

WASHINGTON, July 10, 1865.

THE acceptation of my resignation, tendered on the 8th inst., was received this morning.

I have thus resigned a position in the navy where my professional attainments are most needed, and where my engineering knowledge could not be utilized because there was none in the Navy Department who could appreciate or employ them. There is work in the Bureau of Steam-Engineering for a dozen engineers of my qualifications, and there are now many good mathematicians in that Bureau who would be very glad to undertake such work as is now needed in the organization and instruction of the Engineer Cadets, but there is none in the Department with adequate technical knowledge to take the lead in such an important enterprise.

The Navy Department is apparently unaware that our present scientific books are not only inadequate to meet the requirements of the day, but much of the matter existing in them is very confused, without order or classification, and some of it is not correct. Besides, many of our scientific books contain an unnecessary burden for students.

In the multifarious studies required in our days by Naval Engineers, it is of great importance to economize their time and labors.

The science of dynamics is yet in a very complicated and confused condition, without a specific meaning being attached to the terms employed. Correspondents are constantly seeking information, through scientific journals, on the subject of dynamics, and invariably receive confused answers, in verification of which a few examples may be given.

The *Scientific American*, of November 26, 1864, informs its correspondents that "the size and weight of a fly-wheel must be in proper proportion to the machine which it is designed to regulate, and this is determined by observation and experience; it cannot be calculated by any mathematical rule. Within the limit usually adopted by mechanics, our preference is for light wheels of large diameter, rather than for heavier ones of smaller diameter. The regulating power of fly-wheels is in proportion to their weight multiplied by the square of their velocity."

Here it is asserted that the weight of a fly-wheel must be in proper proportion to the machine! whilst we know that many machines run well without a fly-wheel; its sole function and office is to approach uniformity of motion by regulating alternate irregular work. The *Scientific American* says that "the proper size of the fly-wheel cannot be calculated." The action of a fly-wheel, however, is calculated and determined as easily as a simple problem in geometry; but we have yet no books where this is properly explained.

An English scientific journal informs its correspondents that "the size and weight of fly-wheels are usually determined from practical experiment. There is given an elaborate theory of the fly-wheel in Moseley's *Mechanical Principles of Architecture and Engineering*, but the formulas deduced are very intricate."

The formulas are complicated in Moseley's book because the subject is not properly understood.

The *Scientific American* also for Sept. 10, 1864, informs its correspondents that "when a body is raised slowly, the power required to overcome the inertia is inappreciable, and must be disregarded in reckoning the work done. But when the velocity is appreciable, it must be considered in computing the work. This part of the work is in proportion to the square of the velocity." Now the work required to raise a body is equal to the weight of the body multiplied by the height to which it is raised, independently of velocity. The work expended on the inertia in starting the body, is re-utilized when it is brought to rest. From the *Scientific American,* we may infer that work is required to overcome the inertia, while the body is raised with a uniform velocity.

Another correspondent is informed that "the vis-viva, or force of a moving body, is in proportion to the square of the velocity, and the power required to impart velocity is in the same ratio. It therefore requires an expenditure of four times the force to impart double velocity either to a projectile or to a revolving wheel."

Here *force*, *power*, and *work* are, as usual, confounded with each other. A force of one pound can give as much velocity to a body free to move as a force of a hundred pounds, if time be disregarded. In equal times, the force is directly as the velocity. In equal space, the force is as the square of the velocity; and in equal time and space, the force is inversely as the square of the time.

The science of dynamics is yet in the condition which geometry would be without illustrations. Dynamical quantities are physical operations, and cannot be recognized as material or geometrical objects, but must be conceived from algebraical formulas. But among the very best mathematicians, there are few who can conceive the true configuration of an object when it is simply expressed in a complicated formula. Dynamical quantities, such as *force*, *velocity*, and *time*, and their combinations into *power*, *space*, and *work*, can be compared with and illustrated by geometrical objects, and thus made to present a clear conception to the mind, without which it is often difficult, if not impossible. At least, I have not myself been able to form a clear conception of dynamics without the aid of adequate illustrations.

It yet remains to explain and illustrate how work is accumulated in, and distributed by, a fly-wheel; how the combination and distribution of work in machinery in general is performed —such as the operation of the moving mass in our present propeller-engines, which constitutes a very important item in the success of the machinery; how the work required to transport a given cargo a given distance, in different forms of ships with different speeds is achieved; all this, yet remain a mere conjecture, is spoken of as a craft to be acquired only by experience, and the rationale of the problem has never been given.

I proposed to the Engineer-in-Chief of the Navy, Mr. Isherwood, to clear up this subject of dynamics for the Naval Engineer Cadets, but the proposition was in vain.

Whatever I proposed in that quarter, whether based upon true scientific principles which could not be disputed, or upon ideas which are avowedly in successful operation in different parts of the world, was obdurately declined, and invariably overwhelmed with quack reasoning, informing me that what they already did was perfection, and that every possible idea was exhausted for ages to come.

The disposition to suppose that we have reached perfection actually bars the path of progress in the Navy Department, and that illustrious Chief, with all his talent, will never progress until he finds out that he is behind the time.

In order to clear up the science of dynamics, it will be necessary to abolish a number of useless terms which now confuse the subject, and to establish a specific meaning for the terms retained. To give authority to such a proposition, I submitted a paper on the subject to the National Academy of Sciences, at its meeting last January; but the Academy declined to act upon it, and informed me that the subject has been sufficiently discussed. In a period when steam-engineering is not considered sufficiently important, or is not sufficiently advanced, for the Corps of Naval Engineers to be worthy to be represented in the National Academy of Science, we cannot expect the members of such an Academy to be familiar with, or to appreciate what is wanted in the practical operation of machinery, with which they have no connection.

The science of dynamics is represented in its simple form in the tenth edition of Nystrom's Pocket-Book, but the space is there so crowded, that it does not admit of full explanation with illustrations.

About a year ago, when I told Captain Fox that I had some valuable matter on hand which would be useful for the naval engineer cadets, he answered, "If you have anything new, you just take out a patent for it; we have a patent office for that purpose."

Captain Fox then also told me about what Democratic Governments do not do, and what Monarchical Governments do do, very much in the style of his previous observation.

I wish Captain Fox to know that I believe myself to have a better opinion of a Democratic or Republican form of Government than he has. My humble proposition had nothing whatever to do with the form of Government. Captain Fox, however, left the impression on me that his ideas about Monarchical Governments are what he has learned in Shakspeare, and as it was in Europe a hundred years ago.

The Navy Department is now attempting to reorganize the Corps of Naval Engineers. Captain Fox tries his best to subordinate the engineers to the Line Officers, and the engineers in the Department strain their efforts to secure rank and position, all with self-interest in view, but no proposition seems to be offered to prepare the new corps of engineers (by receiving the proper learning) to maintain with dignity whatever rank and position may be assigned to it. Give the corps a thorough technological education, and it will become able to take care of itself respecting rank and position; for in the present feeble conception of the value and importance of mechanical skill and of the range of knowledge of steam-engineering, now prevalent in the Navy Department, it is useless to argue about questions of rank, position, and responsibility of the corps of engineers.

The Washington Navy Yard contains a very extensive mechanical establishment for the building of marine engines and boilers, the superintendence of which is now intrusted to a mechanic brought up in that place, and with no further scientific education. However accomplished this mechanic might be in his limited profession, he cannot possibly fulfil the requirements of such an establishment in connection with the different mechanic arts and sciences which it involves; neither can he command the respect requisite in the proper execution of such a responsible office.

These remarks were made in the Navy Department, and were answered thus: "All the drawings are made here in minute details, and there is no more knowledge necessary in the yard than to follow the drawings."

Such expressions of disregard for the knowledge required in the execution of work were frequently met with.

The Navy Department, where the drawings are made, is some three miles from the yard where the work is executed. The chief draughtsman visits the works perhaps once a week, and remains there an hour or two, which is considered a sufficient connection between the drawing-room and the workshops. The absurdity of this arrangement can well be conceived, for we know by experience, in well-regulated establishments, that for the proper execution of the drawings, in regard to economy and utility in the work, the draughtsman requires constant access to the patterns, pattern-shop, and to the different branches of the establishment; and that there is constant consultation going on between the draughtsmen and the foremen in the different branches of the mechanic arts.

In Washington these parties are separated by a distance of several miles, in consequence of which the character of design, the economy and the progress of the work, suffer considerably. However able or talented draughtsmen or engineers may be when entering the Navy Department, they will soon be spoiled, which is readily evinced in their fancy design of machinery with mouldings and ornaments, not to be found in our days outside the Bureau of Steam-Engineering.

These draughtsmen, I believe, are all Engineers in the Corps, and seem to display a goodly array of talent. Many of them have received collegiate educations, are accomplished mathematicians, and well versed in the physical sciences, but for want of a technological education, they are naturally deficient in *the application of their scientific knowledge;* and much of what they would be able to apply and cultivate, cannot be utilized when thus separated from the field where the seed of their education ought to be planted.

The Navy Department is now about to pump steam-engineering into Line Officers at the Naval Academy, Annapolis, and to make engine-drivers (as they call it) out of ensigns, masters, and midshipmen, by sending them to sea, and having them stand watch in the engine-room; by which means it is expected to make steam-engineers in the space of two years! How easy the Navy Department must think steam-engineering to be! This mode of making steam-engineers is surely the greatest invention of the age; and Captain Fox, the ostensible author of it, had better take out a *patent* for that bubble before it bursts; "we have a patent office for that purpose."

During the war Captain Fox kept in his room models of machinery and vessels submitted by civilians to the Navy Department. He decided what was to be done and not to be done in questions of naval engineering. He undertook to superintend the construction of vessels in the Bureau of Construction. He selected models for the constructors to make drawings of.

Now, for the sake of argument, let us suppose that Captain Fox is, by nature, gifted with a peculiar faculty which enables him to guess which model of vessel is best for a desired purpose. A vessel is built from that model, and proves to be satisfactory or not. Neither Captain Fox nor the constructors in the navy are yet able to judge or record the peculiarities of that vessel, in form of scientific arguments, why it did or did not come up to what was anticipated. In case it proved to be a good vessel, there might still never be another one built like it, and Captain Fox's superintendence will thus only satisfy his own personal ambition, without leaving recorded and permanent results for the future benefit of the navy.

Now if Captain Fox had allowed the introduction of the science of shipbuilding into the Department, the achievements of his own talent might have been recorded and perpetuated for the benefit of the country.

In my humble judgment, I believe Mr. Lenthal has attained great perfection in the construction of ships, for which reason I was very anxious to give his lines a scientific investigation, but he would not allow me to see his best drawings. The ships' drawings intrusted to me in the Department, through the request of Mr. Isherwood, for information required in the Bureau of Steam-Engineering, were of some twelve different vessels, of which only two were of Mr. Lenthal's construction. It appeared that Mr. Lenthal would not allow me to explore his late ships' drawings, even at the request of Mr. Isherwood. The engineers in the Department are not allowed to see the ship's drawings, except through the kindness of some clerks who, in Mr. Lenthal's absence, run the risk of letting some of them be seen. I did not avail myself of such an opportunity, for although I have the highest regard for Mr. Lenthal as a constructor and shipbuilder, his drawings would not warrant such a proceeding on my part.

The engineers in the Department generally evince a strong appetite for learning, and when I received some few old ships' drawings from the Bureau of Construction, they generally surrounded them with a manifest anxiety to gather information, and remarked that "it must have broken Mr. Lenthal's heart to have given these drawings out of his office."

In case it were the policy of the government to keep their ships' drawings secret from a desire to promote the interest of the country, I would heartily acquiesce; but it is a question of considerable importance whether such a policy would not act detrimentally rather than otherwise.

If a knowledge of shipbuilding is to be restricted only to a chosen few constructors in the navy, it would be by a rare accident only that those of adequate capacity would be hit upon, while if thrown generally open, it would scarcely fail to reach many whose talent in that particular would be unquestionable.

In reality, this attempt at secrecy is a folly, for in view of the conspicuous enterprise and fertility of the American mind, we need not fear to be behind the time by a liberal diffusion of useful knowledge, for unless we sow, there can be no harvest.

The farther we look back on the art of shipbuilding, the more secret it appears to have been kept, until, at the present time, some of our first shipbuilders not only freely expose their drawings to observation, but even allow them to be published.

The lines of the fastest and best of the European steamers, namely, the "Persia," and others, are published in McKensy's Shipbuilding, and those of the "Scotia" also are published in Scott Russel's work.

The sloops of war of the *Wampanoag* class, intended for great speed, we have reason to suppose, have the most perfect lines of the day, which, in connection with their intended great propelling power, afford a very interesting field for scientific investigation, the result of which might be of great value to the Corps of Engineers, but will now probably be lost to them through a personal jealousy.

This jealousy is by no means limited to the Navy Department, but is met with in all directions, and frequently intercepts scientific inquiry. It is an epidemic disease which can be cured only by technological education.

Once, in a scientific meeting, efforts to explain the science of steamboiler explosions, and how to prevent the same, were silenced by the president of the meeting calling me to the chair and whispering, "Don't say anything about boiler explosions." The discussion was accordingly dropped and lost.

An explanation of the cause of steamboiler explosion is a question demonstrably within the reach of science, as much so as a problem of geometry.

In many cases explosions are indicated a long time before they occur, and could be easily prevented. The terrible explosion on board the steamer Sultana, on the Mississippi, and a great many other similar disasters were indicated several hours before they occurred, all of which could have been prevented, and a great number of lives saved. (See Nystrom's Pocket-Book, tenth edition.)

If the president who stopped my discussion on steamboiler explosion, were comfortably seated on the top of a boiler when it exploded, and were blown up a few hundred feet in the air, and came down comfortably and unhurt, it would be interesting to ascertain whether he would stop a discussion on steamboiler explosion at the next meeting.

It will perhaps be remarked that it is very improper to take so much upon myself, and speak so plainly about all these things, as has been done in this book, but I have been kept so long in silence, whilst the neglect and ignorance which still control the subject have consigned so many thousands of souls to heaven, and so many millions of dollars in the opposite direction, that these protestations cannot be suppressed.

The appropriate remedy for the evil is THE ESTABLISHMENT OF TECHNOLOGICAL INSTITUTIONS THROUGHOUT THE LAND.

Practical and Scientific Books,

PUBLISHED BY

HENRY CAREY BAIRD,

INDUSTRIAL PUBLISHER,

No. 406 Walnut Street,
PHILADELPHIA.

☞ **Any of the following Books will be sent by mail, free of postage, at the publication price. Catalogues furnished on application.**

American Miller and Millwright's Assistant:

A new and thoroughly revised Edition, with additional Engravings. By WILLIAM CARTER HUGHES. In one volume, 12 mo., ...$1.25

Armengaud, Amoroux, and Johnson.

THE PRACTICAL DRAUGHTSMAN'S BOOK OF INDUSTRIAL DESIGN, and Machinist's and Engineer's Drawing Companion; forming a complete course of Mechanical Engineering and Architectural Drawing. From the French of M. Armengaud the elder, Prof. of Design in the Conservatoire of Arts and Industry, Paris, and MM. Armengaud the younger, and Amouroux, Civil Engineers. Rewritten and arranged, with additional matter and plates, selections from and examples of the most useful and generally employed mechanism of the day. By William Johnson, Assoc. Inst. C. E., Editor of "The Practical Mechanic's Journal." Illustrated by fifty folio steel plates and fifty wood-cuts. A new edition, 4to., ...$10.00

Among the contents are:—*Linear Drawing, Definitions and Problems,* Plate I. Applications, Designs for inlaid Pavements, Ceilings and Balconies, Plate II. Sweeps, Sections and Mouldings, Plate III. Elementary Gothic Forms and Rosettes, Plate IV. Ovals, Ellipses, Parabolas and Volutes, Plate V. Rules and Practical Data. *Study of Projections*, Elementary Principles, Plate VI. Of Prisms and other Solids, Plate VII. Rules and Practical Data. *On Coloring Sections, with Applications*—Conventional Colors, Composition or Mixture of Colors, Plate X. *Continuation of the Study of Projections*—Use of sections—details of machinery, Plate XI. Simple applications—spindles, shafts, couplings, wooden patterns, Plate XII. Method of constructing a wooden model or pattern of a coupling, Elementary applications—rails and chairs for railways, Plate XIII. *Rules and Practical Data*—Strength of material, Resistance to compression or crushing force, Tensional Resistance, Resistance to flexure, Resistance to torsion, Friction of surfaces in contact.

THE INTERSECTION AND DEVELOPMENT OF SURFACES, WITH APPLICATIONS.—*The Intersection of Cylinders and Cones*, Plate XIV. *The Delineation and Development of Helices, Screws and Serpentines*, Plate XV. Application of the helix—the construction of a staircase, Plate XVI. The Intersection of surfaces—applications to stop-cocks, Plate XVII. *Rules and Practical Data*—Steam, Unity of heat, Heating surface, Calculation of the dimensions of boilers, Dimensions of firegrates, Chimneys, Safety-valves.

THE STUDY AND CONSTRUCTION OF TOOTHED GEAR.—Involute, cycloid, and epicycloid, Plates XVIII. and XIX. Involute, Fig. 1, Plate XVIII. Cycloid, Fig. 2, Plate XVIII. External epicycloid, described by a circle rolling about a fixed circle inside it, Fig. 3, Plate XIX. Internal epicycloid, Fig. 2, Plate XIX. Delineation of a rack and pinion in gear, Fig. 4, Plate XVIII. Gearing of a worm with a worm-wheel, Figs. 5 and 6, Plate XVIII. *Cylindrical or Spur Gearing*, Plate XIX. Practical delineation of a couple of Spur-wheels, Plate XX. *The Delineation and Construction of Wooden Patterns for Toothed Wheels*, Plate XXI. *Rules and Practical Data*—Toothed gearing, Angular and circumferential velocity of wheels, Dimensions of gearing, Thickness of the teeth, Pitch of the teeth, Dimensions of the web, Number and dimensions of the arms, wooden patterns.

CONTINUATION OF THE STUDY OF TOOTHED GEAR.—Design for a pair of bevel-wheels in gear, Plate XXII. Construction of wooden patterns for a pair of bevel-wheels, Plate XXIII. *Involute and Helical Teeth*, Plate XXIV. *Contrivances for obtaining Differential Movements*—The delineation of eccentrics and cams, Plate XXV. *Rules and Practical Data*—Mechanical work of effect, The simple machines, Centre of gravity, On estimating the power of prime movers, Calculation for the brake, The fall of bodies, Momentum, Central forces.

ELEMENTARY PRINCIPLES OF SHADOWS.—*Shadows of Prisms, Pyramids and Cylinders*, Plate XXVI. *Principles of Shading*, Plate XXVII. *Continuation of the Study of Shadows*, Plate XXVIII. *Tuscan Order*, Plate XXIX. *Rules and Practical Data*—Pumps, Hydrostatic principles, Forcing pumps, Lifting and forcing pumps, The Hydrostatic press, Hydrostatical calculations and data—discharge of water through different orifices, Gaging of a water-course of uniform section and fall, Velocity of the bottom of water-courses, Calculation of the discharge of water through rectangular orifices of narrow edges, Calculation of the discharge of water through overshot outlets, To determine the width of an overshot outlet, To determine the depth of the outlet, Outlet with a spout or duct.

APPLICATION OF SHADOWS TO TOOTHED GEAR, Plate XXX. *Application of Shadows to Screws*, Plate XXXI. *Application of Shadows to a Boiler and its Furnace*, Plate XXXII. *Shading in Black—Shading in Colors*, Plate XXXIII.

THE CUTTING AND SHAPING OF MASONRY, Plate XXXIV. *Rules and Practical Data*—Hydraulic motors, Undershot water wheels, with plane floats and a circular channel, Width, Diameter, Velocity, Number and capacity of the buckets, Useful effect of the water wheel, Overshot water wheels, Water wheels with radial floats, Water wheel with curved buckets, Turbines. *Remarks on Machine Tools.*

THE STUDY OF MACHINERY AND SKETCHING.—Various applications and combinations: *The Sketching of Machinery*, Plates XXXV. and XXXVI. *Drilling Machine; Motive Machines;* Water wheels, Construction and setting up of water wheels, Delineation of water wheels, Design for a water wheel, Sketch of a water wheel; *Overshot Water Wheels. Water Pumps*, Plate XXXVII. *Steam Motors;* High-pressure expansive steam engine, Plates XXXVIII., XXXIX. and XL. *Details of Construction; Movements of the Distribution and Expansion Valves; Rules and Practical Data*—Steam engines: Low-pressure condensing engines without expansion valve, Diameter of piston, Velocities, Steam pipes and passages, Air-pump and condenser, Cold-water and feed-pumps, High-pressure expansive engines, Medium pressure condensing and expansive steam engine, Conical pendulum or centrifugal governor.

OBLIQUE PROJECTIONS.—Application of rules to the delineation of an oscillating cylinder, Plate XLI.

PARALLEL PERSPECTIVE.—Principles and applications, Plate XLII.

TRUE PERSPECTIVE.—Elementary principles, Plate XLIII. Applications—flour mill driven by belts, Plates XLIV. and XLV. Description of the mill, Representation of the mill in perspective, Notes of recent improvements in flour mills, Schiele's mill, Mullin's "ring millstone," Barnett's millstone, Hastie's arrangement for driving mills, Currie's improvements in millstones; *Rules and Practical Data*—Work performed by various machines, Flour mills, Saw mills, Veneer-sawing machines, Circular saws.

EXAMPLES OF FINISHED DRAWINGS OF MACHINERY.—Plate A, Balance water-meter; Plate B, Engineer's shaping machine; Plate C D E, Express locomotive engine; Plate F., Wood planing machine; Plate G, Washing machine for piece goods; Plate H, power loom; Plate I, Duplex steam boiler; Plate J, Direct-acting marine engines.

DRAWING INSTRUMENTS.

Blinn. A Practical Workshop Companion for Tin, Sheet-Iron, and Copper-Plate Workers:

Containing Rules for Describing various kinds of Patterns used by Tin, Sheet-Iron, and Copper-Plate Workers; Practical Geometry; Mensuration of Surfaces and Solids; Tables of the Weights of Metals, Lead Pipe, etc.; Tables of Areas and Circumferences of Circles; Japans, Varnishes, Lackers, Cements, Compositions, etc. etc. By Leroy J. Blinn. With numerous Illustrations. 12mo.........$2.50

Beans. A Treatise on Railroad Curves and the Location of Railroads.

By E. W. Beans, C. E. 12mo. (In press.)

Bishop. A History of American Manufactures,

From 1608 to 1860; exhibiting the Origin and Growth of the Principal Mechanic Arts and Manufactures, from the Earliest Colonial Period to the Present Time; with a

Notice of the Important Inventions, Tariffs, and the Results of each Decennial Census. By J. Leander Bishop, M. D, : to which is added Notes on the Principal Manufacturing Centres and Remarkable Manufactories. By Edward Young and Edwin T. Freedley. In two vols., 8vo. $6.00

Bookbinding: A Manual of the Art of Book binding,

Containing full instructions in the different branches of Forwarding, Gilding and Finishing. Also, the Art of Marbling Book-edges and Paper. By James B. Nicholson. Illustrated. 12mo., cloth, ... $2.25

CONTENTS.—Sketch of the Progress of Bookbinding, Sheet-work, Forwarding the Edges, Marbling, Gilding the Edges, Covering, Half Binding, Blank Binding, Boarding, Cloth-work, Ornamental Art, Finishing, Taste and Design, Styles, Gilding, Illuminated Binding, Blind Tooling, Antique, Coloring, Marbling, Uniform Colors, Gold Marbling, Landscapes, etc., Inlaid Ornaments, Harmony of Colors, Pasting Down, etc., Stamp or Press-work, Restoring the Bindings of Old Books, Supplying imperfections in Old Books, Hints to Book Collectors, Technical Lessons.

Booth and Morfit. The Encyclopedia of Chemistry, Practical and Theoretical:

Embracing its application to the Arts, Metallurgy, Mineralogy, Geology, Medicine, and Pharmacy, By James C. Booth, Melter and Refiner in the United States Mint; Professor of Applied Chemistry in the Franklin Institute, etc.; assisted by Campbell Morfit, author of "Chemical Manipulations," etc. 7th Edition. Complete in one volume, royal octavo, 978 pages, with numerous wood cuts and other illustrations, ... $5.00

From the very large number of articles in this volume, it is entirely impossible to give a list of the Contents, but attention may be called to some among the more elaborate, such as Affinity, Alcoholometry, Ammonium, Analysis, Antimony, Arsenic, Blowpipes, Cyanogen, Distillation, Electricity, Ethyl, Fermentation, Iron, Lead and Water.

Brewer; (The Complete Practical.)

Or Plain, Concise, and Accurate Instructions in the Art of Brewing Beer, Ale, Porter, etc., etc., and the Process of Making all the Small Beers. By M. Lafayette Byrn, M. D. With Illustrations. 12mo $1.25

"Many an old brewer will find in this book valuable hints and suggestions worthy of consideration, and the novice can post himself up in his trade in all its parts."—*Artisan.*

Builder's Pocket Companion:

Containing the Elements of Building, Surveying, and Architecture; with Practical Rules and Instructions connected with the subject. By A. C. SMEATON, Civil Engineer, etc. In one volume, 12mo., ...$1.25

CONTENTS.—The Builder, Carpenter, Joiner, Mason, Plasterer, Plumber, Painter, Smith, Practical Geometry, Surveyor, Cohesive Strength of Bodies, Architect.

"It gives, in a small space, the most thorough directions to the builder, from the laying of a brick, or the felling of a tree, up to the most elaborate production of ornamental architecture. It is scientific, without being obscure and unintelligible; and every house-carpenter, master, journeyman, or apprentice, should have a copy at hand always."—*Evening Bulletin.*

Byrne. The Handbook for the Artisan, Mechanic, and Engineer,

Containing Instructions in Grinding and Sharpening of Cutting Tools, Figuration of Materials by Abrasion, Lapidary Work, Gem and Glass Engraving, Varnishing and Lackering, Abrasive Processes, etc., etc. By Oliver Byrne. Illustrated with 11 large plates and 185 cuts. 8vo., cloth,..$5.00

CONTENTS.—Grinding Cutting Tools on the Ordinary Grindstone; Sharpening Cutting Tools on the Oilstone; Setting Razors; Sharpening Cutting Tools with Artificial Grinders; Production of Plane Surfaces by Abrasion; Production of Cylindrical Surfaces by Abrasion; Production of Conical Surfaces by Abrasion; Production of Spherical Surfaces by Abrasion; Glass Cutting; Lapidary Work; Setting, Cutting, and Polishing Flat and Rounded Works; Cutting Faucets; Lapidary Apparatus for Amateurs; Gem and Glass Engraving; Seal and Gem Engraving; Cameo Cutting; Glass Engraving, Varnishing, and Lackering; General Remarks upon Abrasive Processes; Dictionary of Apparatus; Materials and Processes for Grinding and Polishing commonly employed in the Mechanical and Useful Arts.

Byrne. The Practical Metal-worker's Assistant,

For Tin-plate Workers, Braziers, Coppersmiths, Zinc-plate Ornrmenters and Workers, Wire Workers, Whitesmiths, Blacksmiths, Bell Hangers, Jewellers, Silver and Gold Smiths, Electrotypers, and all other Workers in Alloys and Metals. Edited by OLIVER BYRNE. Complete in one volume, octavo,......................................$7.00

It treats of Casting, Founding, and Forging; of Tongs and other Tools; Degrees of Heat and Management of Fires; Welding of

Heading and Swage Tools; of Punches and Anvils; of Hardening and Tempering; of Malleable Iron Castings, Case Hardening, Wrought and Cast Iron; the Management and Manipulation of Metals and Alloys, Melting and Mixing; the Management of Furnaces, Casting and Founding with Metallic Moulds, Joining and Working Sheet Metal; Peculiarities of the different Tools employed; Processes dependent on the ductility of Metals; Wire Drawing, Drawing Metal Tubes, Soldering; The use of the Blowpipe, and every other known Metal Worker's Tool.

Byrne. The Practical Model Calculator,

For the Engineer, Machinist, Manufacturer of Engine Work, Naval Architect, Miner, and Millwright. By Oliver Byrne, Compiler and Editor of the Dictionary of Machines, Mechanics, Engine Work and Engineering, and Author of various Mathematical and Mechanical Works. Illustrated by numerous engravings. Complete in one large volume, octavo, of nearly six hundred pages,..$4.50

The principal objects of this work are: to establish model calculations to guide practical men and students; to illustrate every practical rule and principle by numerical calculations, systematically arranged; to give information and data indispensable to those for whom it is intended, thus surpassing in value any other book of its character; to economize the labor of the practical man, and to render his every-day calculations easy and comprehensive. It will be found to be one of the most complete and valuable practical books ever published.

Cabinetmaker's and Upholsterer's Companion,

Comprising the Rudiments and Principles of Cabinetmaking and Upholstery, with Familiar Instructions, illustrated by Examples for attaining a proficiency in the Art of Drawing, as applicable to Cabinet Work; the processes of Veneering, Inlaying, and Buhl Work; the Art of Dyeing and Staining Wood, Bone, Tortoise Shell, etc. Directions for Lackering, Japanning, and Varnishing; to make French Polish; to prepare the best Glues, Cements, and Compositions, and a number of Receipts particularly useful for Workmen generally. By J. Stokes. In one volume, 12mo. With Illustrations,.......... $1.25

"A large amount of practical information, of great service to all concerned in those branches of business."

Campin. A Practical Treatise on Mechanical Engineering;

Comprising Metallurgy, Moulding, Casting, Forging, Tools, Workshop Machinery, Mechanical Manipulation, Manufacture of Steam Engines, etc. etc. With an Appendix on the Analysis of Iron and Iron Ores. By Francis Campin, C. E. To which are added, Observations on the

Construction of Steam Boilers and remarks upon Furnaces used for Smoke Prevention; with a Chapter on Explosions. By R. Armstrong, C. E., and John Bourne. Rules for Calculating the Change Wheels for Screws on a Turning Lathe, and for a Wheel-cutting Machine. By J. La Nicca. Management of Steel, including Forging, Hardening, Tempering, Annealing, Shrinking, and Expansion. And the Case-hardening of Iron. By G. Ede. 8vo. Illustrated with 29 plates and 100 wood engravings. 8vo..................$6.00

Colburn. The Locomotive Engine;

Including a Description of its Structure, Rules for Estimating its Capabilities, and Practical Observations on its Construction and Management. By Zerah Colburn. Illustrated. A new edition. 12mo,.....................$1.25

"It is the most practical and generally useful work on the Steam Engine that we have seen."—*Boston Traveler.*"

Daguerreotypist and Photographer's Companion.

12mo., cloth,..$1.25

Distiller (The Complete Practical).

By M. Lafayette Byrn, M.D. With Illustrations. 12mo. $1.25

"So simplified. that it is adapted not only to the use of extensive Distillers, but for every farmer, or others who may want to engage in Distilling."—*Banner of the Union.*

Dussauce. Practical Treatise

On the Fabrication of Matches, Gun Cotton, and Fulminating Powders. By Prof. H. Dussauce. 12mo.,....$3.00

CONTENTS.—*Phosphorus.*—History of Phosphorus; Physical Properties; Chemical Properties; Natural State; Preparation of White Phosphorus; Amorphous Phosphorus, and Benoxide of Lead. *Matches.*—Preparation of Wooden Matches; Matches inflammable by rubbing, without noise; Common Lucifer Matches: Matches without Phosphorus; Candle Matches; Matches with Amorphous Phosphorus; Matches and Rubbers without Phosphorus. *Gun Cotton.*—Properties; Preparation; Paper Powder; use of Cotton and Paper Powders for Fulminating Primers, etc.; Preparation of Fulminating Primers, etc., etc.

Dussauce. Chemical Receipt Book:

A General Formulary for the Fabrication of Leading Chemicals, and their Application to the Arts, Manufactures, Metallurgy, and Agriculture. By Prof. H. Dussauce. (*In press.*)

7

DYEING, CALICO PRINTING, COLORS, COTTON SPINNING, AND WOOLEN MANUFACTURE.

Baird. The American Cotton Spinner, and Manager's and Carder's Guide:

A Practical Treatise on Cotton Spinning; giving the Dimensions and Speed of Machinery, Draught and Twist Calculations, etc.; with Notices of recent Improvements: together with Rules and Examples for making changes in the sizes and numbers of Roving and Yarn. Compiled from the papers of the late Robert H. Baird. 12mo..$1.25

Capron De Dole. Dussauce. Blues and Carmines of Indigo:

A Practical Treatise on the Fabrication of every Commercial Product derived from Indigo. By Felicieu Capron de Dole. Translated, with important additions, by Professor H. Dussauce. 12mo....................................$2.50

Chemistry Applied to Dyeing.

By James Napier, F. C. S. Illustrated. 12mo........$2.50

CONTENTS.—*General Properties of Matter.*—Heat, Light, Elements of Matter, Chemical Affinity. *Non-Metallic Substances.*—Oxygen, Hydrogen, Nitrogen, Chlorine, Sulphur, Selenium, Phosphorus, Iodine, Bromine, Fluorine, Silicum, Boron, Carbon. *Metallic Substances.*—General Properties of Metals, Potassium, Sodium, Lithium, Soap, Barium, Strontium, Calcium, Magnesium, Alminum, Manganese, Iron, Cobalt, Nickel, Zinc, Cadmium, Copper, Lead, Bismuth, Tin, Titanium, Chromium, Vanadium, Tungstenum or Wolfram, Molybdenum, Tellarium, Arsenic, Antimony, Uranium, Cerium, Mercury, Silver, Gold, Platinum, Palladium, Iridium, Osmium, Rhodium, Lanthanium. *Mordants.*—Red Spirits, Barwood Spirits, Plumb Spirits, Yellow Spirits, Nitrate of Iron, Acetate of Alumina, Black Iron Liquor, Iron and Tin for Royal Blues, Acetate of Copper. *Vegetable Matters used in Dyeing.*—Galls, Sumach, Catechu, Indigo, Logwood, Brazil-woods, Sandal-wood, Barwood, Camwood, Fustic, Young Fustic, Bark or Quercitron, Flavine, Weld or Wold, Turmeric, Persian Berries, Safflower, Madder, Munjeet, Annota, Alkanet Root, Archil. *Proposed New Vegetable Dyes.*—Sooranjee, Carajuru, Wongshy, Aloes, Pittacal, Barbary Root. *Animal Matters used in Dyeing.*—Cochineal, Lake or Lac, Kerms.

This will be found one of the most valuable books on the subject of dyeing, ever published in this country.

Dussauce. Treatise on the Coloring Matters Derived from Coal Tar;

Their Practical Application in Dyeing Cotton, Wool, and

Silk; the Principles of the Art of Dyeing and of the Distillation of Coal Tar; with a Description of the most Important New Dyes now in use. By Professor H. Dussauce, Chemist. 12mo..$2.50

CONTENTS.—Historical Notice of the Art of Dyeing—Chemical Principles of the Art of Dyeing—Preliminary Preparation of Stuffs—Mordants—Dyeing—On the Coloring Matters produced by Coal Tar—Distillation of Coal Tar—History of Aniline—Properties of Aniline—Preparation of Aniline directly from Coal Tar—Artificial Preparation of Aniline—Preparation of Benzole—Properties of Benzole—Preparation of Nitro-Benzole—Transformation of Nitro-Benzole into Aniline, by means of Sulphide of Ammonium; by Nascent Hydrogen; by Acetate of Iron; and by Arsenite of Potash—Properties of the Bi-Nitro-Benzole—Aniline Purple—Violine—Roseine—Emeraldine—Bleu de Paris—Futschine, or Magenta—Coloring Matters obtained by other bases from Coal Tar—Nitroso-Phenyline—Di Nitro-Aniline—Nitro-Phenyline—Picric Acid—Rosolic Acid—Quinoline—Napthaline Colors—Chloroxynaphthalic and Perchloroxynapthalic Acids—Carminaphtha—Ninaphthalamine—Nitrosonaphthaline—Naphthamein—Tar Red—Azuline—Application of Coal Tar Colors to the Art of Dyeing and Calico Printing—Action of Light on Coloring Matters from Coal Tar—Latest Improvements in the Art of Dyeing—Chrysammic Acid—Molybdic and Picric Acids—Extract of Madder—Theory of the Fixation of Coloring Matters in Dyeing and Printing—Principles of the Action of the most important Mordants—Aluminous Mordants—Ferruginous Mordants—Stanniferous Mordants—Artificial Alizarin—Metallic Hyposulphites as Mordants—Dyer's Soap—Preparation of Indigo for Dyeing and Printing—Relative Value of Indigo—Chinese Green Murexide.

Dyer and Color-maker's Companion:

Containing upwards of two hundred Receipts for making Colors, on the most approved principles, for all the various styles and fabrics now in existence; with the Scouring Process, and plain Directions for Preparing, Washing-off, and Finishing the Goods. Second edition. In one volume, 12mo..$1.25

French Dyer, (The):

Comprising the Art of Dyeing in Woolen, Silk, Cotton, etc., etc. By M. M. Riffault, Vernaud, De Fontenelle, Thillaye, and Mallepeyre. (*In press.*)

Love. The Art of Dyeing, Cleaning, Scouring, and Finishing,

On the Most Approved English and French Methods; being Practical Instructions in Dyeing Silks, Woolens and Cottons, Feathers, Chips, Straw, etc., Scouring and Cleaning Bed and Window Curtains, Carpets, Rugs, etc., French and English Cleaning, any Color or Fabric of Silk, Satin, or Damask. By Thomas Love, a working Dyer and Scourer. In one volume, 12mo...............$3.00

O'Neill. Chemistry of Calico Printing, Dyeing, and Bleaching;

Including Silken, Woolen, and Mixed Goods; Practical and Theoretical. By Charles O'Neill. *(In press.)*

O'Neill. A Dictionary of Calico Printing and Dyeing.

By Charles O'Neill. *(In press.)*

Scott. The Practical Cotton-spinner and Manufacturer;

OR, THE MANAGER AND OVERLOOKER'S COMPANION. This work contains a Comprehensive System of Calculations for Mill Gearing and Machinery, from the first Moving Power, through the different processes of Carding, Drawing, Slabbing, Roving, Spinning, and Weaving, adapted to American Machinery, Practice and Usages. Compendious Tables of Yarns and Reeds are added. Illustrated by large Working-Drawings of the most approved American Cotton Machinery. Complete in one volume, octavo..$5.00

This edition of Scott's Cotton-Spinner, by Oliver Byrne, is designed for the American Operative. It will be found intensely practical, and will be of the greatest possible value to the Manager, Overseer, and Workman.

Sellers. The Color-mixer.

By John Sellers, an Experienced Practical Workman. To which is added a CATECHISM OF CHEMISTRY. In one volume, 12mo..$2.50

Smith. The Dyer's Instructor;

Comprising Practical Instructions in the Art of Dyeing Silk, Cotton, Wool and Worsted, and Woolen Goods, as Single and Two-colored Damasks, Moreens, Camlets, Lastings, Shot Cobourgs, Silk Striped Orleans, Plain Orleans, from White and Colored Warps, Merinos, Woolens, Yarns, etc.; containing nearly eight hundred Receipts. To which is added a Treatise on the Art of Padding, and the Printing of Silk Warps, Skeins and Handkerchiefs, and the various Mordants and Colors for the different styles of such work. By David Smith, Pattern Dyer. A new edition, in one volume, 12mo....................$3.00

CONTENTS.—Wool Dyeing, 60 receipts—Cotton Dyeing, 68 receipts—Silk Dyeing, 60 receipts—Woolen Yarn Dyeing, 59 receipts—Worsted Yarn Dyeing, 51 receipts—Woolen Dyeing, 52 receipts—Damask Dyeing, 40 receipts—Moreen Dyeing, 38 receipts—Two-Colored Damask Dyeing, 21 receipts—Camlet Dyeing, 23 receipts—Lasting Dyeing, 23 receipts—Shot Cobourg Dyeing, 18 receipts—Silk Striped Orleans, from Black, White, and Colored Warps, 23 receipts—Colored Orleans, from Black Warps, 15 receipts—Colored Orleans and Cobourgs, from White Warps, 27 receipts—Colored Merinos, 41 receipts—Woolen Shawl Dyeing, 15 receipts—Padding, 42 receipts—Silk Warp, Skein, and Handkerchief Printing, 62 receipts—Nature and Use of Dyewares, including Alum, Annotta, Archil, Ammonia, Argol, Super Argol, Camwood, Catechu, Cochineal, Chrome, or Bichromate of Potash, Cudbear, Chemic, or Sulphate of Indigo, French Berry, or Persian Berry, Fustic or Young Fustic, Galls, Indigo, Kermes or Lac Dye, Logwood, Madder, Nitric Acid or Aqua Fortis, Nitrates, Oxalic Tin, Peachwood, Prussiate of Potash, Quercitron Bark, Safflower, Saunders or Red Sandal, Sapan Wood, Sumach, Turmeric, Examination of Water by Tests, etc., etc.

Ulrich. Dussauce. A Complete Treatise

ON THE ART OF DYEING COTTON AND WOOL, AS PRACTISED IN PARIS, ROUEN, MULHOUSE AND GERMANY. From the French of M. Louis Ulrich, a Practical Dyer in the principal Manufactories of Paris, Rouen, Mulhouse, etc., etc.; to which are added the most important Receipts for Dyeing Wool, as practised in the Manufacture Imperiale des Gobelins, Paris. By Professor H. Dussauce. 12mo..$3.00

CONTENTS.—

Rouen Dyes,	106	Receipts.
Alsace "	235	"
German "	109	"
Mulhouse "	72	"
Parisian "	56	"
Gobelins "	100	"

In all nearly 700 Receipts.

◆

Easton. A Practical Treatise on Street or Horse-power Railways;

Their Location, Construction and Management; with general Plans and Rules for their Organization and Operation; together with Examinations as to their Comparative Advantages over the Omnibus System, and Inquiries as to their Value for Investment; including Copies of Municipal Ordinances relating thereto. By Alexander Easton, C. E. Illustrated by twenty-three plates, 8vo., cloth..$2.00

Examinations of Drugs, Medicines, Chemicals, etc.,

As to their Purity and Adulterations. By C. H. Peirce, M. D. 12mo., cloth..$2.50

Fisher's Photogenic Manipulation.

16mo., cloth.. 62

Gas and Ventilation;

A Practical Treatise on Gas and Ventilation. By E. E Perkins. 12mo., cloth...$1.00

Gilbart. A Practical Treatise on Banking.

By James William Gilbart, F. R. S. A new enlarged and improved edition. Edited by J. Smith Homans, editor of "Banker's Magazine." To which is added "Money," by H. C. Carey. 8vo...$3.50

Gregory's Mathematics for Practical Men;

Adapted to the Pursuits of Surveyors, Architects, Mechanics and Civil Engineers. 8vo., plates, cloth...$2.25

Hardwich. A Manual of Photographic Chemistry;

Including the practice of the Collodion Process. By J. F. Hardwich. (*In press.*)

Hay. The Interior Decorator;

The Laws of Harmonious Coloring adapted to Interior Decorations; with a Practical Treatise on House Painting. By D. R. Hay, House Painter and Decorator. Illustrated by a Diagram of the Primary, Secondary and Tertiary Colors. 12mo. (*In press.*)

Inventor's Guide—Patent Office and Patent Laws:

Or, a Guide to Inventors, and a Book of Reference for Judges, Lawyers, Magistrates, and others. By J. G. Moore. 12mo., cloth..$1.25

Jervis. Railway Property. A Treatise

On the Construction and Management of Railways; designed to afford useful knowledge, in the popular style, to the holders of this class of property; as well as Railway Managers, Officers and Agents. By John B. Jervis, late Chief Engineer of the Hudson River Railroad, Croton Aqueduct, etc. One volume, 12mo., cloth.......$2.00

CONTENTS.—Preface—Introduction. *Construction.*—Introductory—Land and Land Damages—Location of Line—Method of Business—Grading—Bridges and Culverts—Road Crossings—Ballasting Track—Cross Sleepers—Chairs and Spikes—Rails—Station Buildings—Locomotives, Coaches and Cars. *Operating.*—Introductory—Freight—Passengers—Engine Drivers—Repairs to Track—Repairs of Machinery—Civil Engineer—Superintendent—Supplies of Material—Receipts—Disbursements—Statistics—Running Trains—Competition—Financial Management—General Remarks.

Johnson. The Coal Trade of British America;

With Researches on the Characters and Practical Values of American and Foreign Coals. By Walter R. Johnson, Civil and Mining Engineer and Chemist. 8vo........$2.00

This volume contains the results of the experiments made for the Navy Department, upon which their Coal contracts are now based.

Johnston. Instructions for the Analysis of Soils, Limestones and Manures.

By J. F. W. Johnston. 12mo................................ 38

Larkin. The Practical Brass and Iron Founder's Guide;

A Concise Treatise on the Art of Brass Founding, Moulding, etc. By James Larkin. 12mo., cloth............$1.25

Leslie's (Miss) Complete Cookery;

Directions for Cookery in its Various Branches. By Miss Leslie. 58th thousand. Thoroughly revised; with the addition of New Receipts. In one volume, 12mo., half bound, or in sheep..$1.25

Leslie's (Miss) Ladies' House Book;

A Manual of Domestic Economy. 20th revised edition. 12mo., sheep $1.25

Leslie's (Miss) Two Hundred Receipts in French Cookery.

Cloth, 12mo.. 25

Lieber. Assayer's Guide;

Or, Practical Directions to Assayers, Miners and Smelters, for the Tests and Assays, by Heat and by Wet Processes, of the Ores of all the principal Metals, and of Gold and Silver Coins and Alloys. By Oscar M. Lieber, late Geologist to the State of Mississippi. 12mo. With illustrations $1.25

"Among the indispensable works for this purpose, is this little guide."—*Artizan.*

Lowig. Principles of Organic and Physiological Chemistry.

By Dr. Carl Löwig, Doctor of Medicine and Philosophy; Ordinary Professor of Chemistry in the University of Zürich; Author of "Chemie des Organischen Verbindungen." Translated by Daniel Breed, M. D., of the U. S. Patent Office; late of the Laboratory of Liebig and Lowig. 8vo., sheep..$3.50

Marble Worker's Manual;

Containing Practical Information respecting Marbles in general, their Cutting, Working and Polishing, Veneering, etc., etc. 12mo., cloth.................................$1.25

Miles. A Plain Treatise on Horse-shoeing.

With Illustrations. By William Miles, Author of "The Horse's Foot."... $1.00

Main & Brown. The Marine Steam-Engine.

By Thomas J. Main, F.R. Ast. S. Mathematical Professor at the Royal Naval College, Portsmouth, and Thomas Brown, Assoc. Inst. C. E. Chief Engineer R. N. attached to the Royal Naval College. Authors of "Questions Connected with the Marine Steam-Engine," and the "Indicator and Dynamometer." With Numerous Illustrations. In one Volume, 8vo..$5.00

CONTENTS.—Introductory Chapter, The Boiler, The Engine, Getting up Steam, Duties to Machinery when under Steam, Duties to Engine, &c., on arriving in harbor, Miscellaneous, Appendix.

Main & Brown. Questions on Subjects Connected with the Marine-Steam Engine,

And Examination Papers; with Hints for their Solution. By Thomas J. Main, Professor of Mathematics Royal Naval College, and Thomas Brown, Chief Engineer R. N. 12mo., cloth..$1.50

Main & Brown. The Indicator and Dynamometer,

With their Practical Applications to the Steam Engine. By Thomas J. Main and Thomas Brown. With Illustrations. 8vo., cloth..$1.50

Morfit. A Treatise on Chemistry

Applied to the Manufacture of Soap and Candles; being a Thorough Exposition, in all their Minutiæ, of the principles and Practice of the Trade, based upon the most recent Discoveries in Science and Art. By Campbell Morfit, Professor of Analytical and Applied Chemistry in the University of Maryland. A new and improved edition. Illustrated with 260 Engravings on Wood. Complete in one volume, large 8vo..$7.50

CONTENTS.—CHAPTER I. The History of the Art and its Relations to Science—II. Chemical Combination—III. Alkalies and Alkaline Earths—IV. Alkalimentary—V. Acids—VI. Origin and Composition of Fatty Matters—VII. Saponifiable Fats—Vegetable Fats—Animal Fats—Waxes—VIII. Action of Heat and Mineral Acids of Fatty Matters—IX. Volatile or Essential Oils, and Resins—X. The Proximate Principles of Fats—Their Composition and Properties—Basic Constituents of Fats—XI. Theory of Saponification—XII. Utensils Requisite for a Soap Factory—XIII. Preparatory Manipulations in the Process of Making Soap—Preparation of the Lyes—XIV. Hard

Soaps—XV. Soft Soaps—XVI. Soaps by the Cold Process—XVII. Silicated Soaps—XVIII. Toilet Soaps—XIX. Patent Soaps—XX. Fraud and Adulterations in the Manufacture of Soap—XXI. Candles—XXII. Illumination—XXIII. Philosophy of Flame—XXIV. Raw Material for Candles—Purification and Bleaching of Suet—XXV. Wicks—XXVI. Dipped Candles—XXVII. Moulded Candles—XXVIII. Stearin Candles—XXIX. Stearic Acid Candles—"Star" or "Adamantine" Candles—Saponification by Lime—Saponification by Lime and Sulphurous Acid—Saponification by Sulphuric Acid—Saponification by the combined action of Heat, Pressure and Steam—XXX. Spermaceti Candles—XXXI. Wax Candles—XXXII. Composite Candles—XXXIII. Paraffin—XXXIV. Patent Candles—XXXV. Hydrometers and Thermometers.

Mortimer. Pyrotechnist's Companion;

Or, a Familiar System of Fire-works. By G. W. Mortimer. Illustrated by numerous Engravings. 12mo $1.25

Napier. Manual of Electro-Metallurgy;

Including the Application of the Art to Manufacturing Processes. By James Napier. From the second London edition, revised and enlarged. Illustrated by Engravings. In one volume, 12mo.................................$1.50

Napier's Electro-Metallurgy is generally regarded as the very best Practical Treatise on the Subject in the English Language.

CONTENTS.—History of the Art of Electro-Metallurgy—Description of Galvanic Batteries, and their respective Peculiarities—Electrotype Processes—Miscellaneous Applications of the Process of Coating with Copper—Bronzing—Decomposition of Metals upon one another—Electro-Plating—Electro-Gilding—Results of Experiments on the Deposition of other Metals as Coatings, Theoretical Observations.

Norris's Hand-book for Locomotive Engineers and Machinists;

Comprising the Calculations for Constructing Locomotives, Manner of setting Valves, etc., etc. By Septimus Norris, Civil and Mechanical Engineer. In one volume, 12mo., with Illustrations.................................$2.00

"With pleasure do we meet with such a work as Messrs. Norris and Baird have given us."—*Artizan.*

"In this work he has given us what are called 'the secrets of the business,' in the rules to construct locomotives, in order that the million should be learned in all things."—*Scientific American.*

Nystrom. A Treatise on Screw-Propellers and their Steam-Engines;

With Practical Rules and Examples by which to Calculate and Construct the same for any description of Vessels. By J. W. Nystrom. Illustrated by over thirty large Working Drawings. In one volume, octavo...$6.00

Overman. The Manufacture of Iron in all its Various Branches;

To which is added an Essay on the Manufacture of Steel. By Frederick Overman, Mining Engineer. With one hundred and fifty Wood Engravings. Third edition. In one volume, octavo, five hundred pages..................$7.50

"We have now to announce the appearance of another valuable work on the subject, which, in our humble opinion, supplies any deficiency which late improvements and discoveries may have caused, from the lapse of time since the date of 'Mushet' and 'Schrivenor.' It is the production of one of our Trans-Atlantic brethren, Mr. Frederick Overman, Mining Engineer; and we do not hesitate to set it down as a work of great importance to all connected with the iron interests; one which, while it is sufficiently technological fully to explain chemical analysis, and the various phenomena of iron under different circumstances, to the satisfaction of the most fastidious, is written in that clear and comprehensive style as to be available to the capacity of the humblest mind, and consequently will be of much advantage to those works where the proprietors may see the desirability of placing it in the hands of their operatives."—*London Mining Journal.*

Painter, Gilder and Varnisher's Companion;

Containing Rules and Regulations in every thing relating to the Arts of Painting, Gilding, Varnishing and Glass Staining; with numerous useful and valuable Receipts; Tests for the detection of Adulterations in Oils and Colors; and a statement of the Diseases and Accidents to which Painters, Gilders and Varnishers are particularly liable, with the simplest methods of Prevention and Remedy. Eighth edition. To which are added Complete Instructions in Graining, Marbling, Sign Writing, and Gilding on Glass. 12mo., cloth.............................$1.25

Paper-Hanger's (The) Companion;

In which the Practical Operations of the Trade are systematically laid down; with copious Directions Preparatory to Papering; Preventions against the effect of Damp in Walls; the various Cements and Pastes adapted to the several purposes of the Trade; Observations and Directions for the Panelling and Ornamenting of Rooms, etc., etc. By James Arrowsmith. In one volume 12mo $1.25

Practical (The) Surveyor's Guide;

Containing the necessary information to make any person of common capacity a finished Land Surveyor, without the aid of a Teacher. By Andrew Duncan, Land Surveyor and Civil Engineer. 12mo....................$1.25

Having had an experience as a Practical Surveyor, etc., of thirty years, it is believed that the author of this volume possesses a thorough knowledge of the wants of the profession; and never having met with any work sufficiently concise and instructive in the several details necessary for the proper qualification of the Surveyor, it has been his object to supply that want. Among other important matters in the book, will be found the following:

Instructions in levelling and profiling, with a new and speedy plan of setting grades on rail and plank roads—the method of inflecting curves—the description and design of a new instrument, whereby distances are found at once, without any calculation—a new method of surveying any tract of land by measuring one line through it—a geometrical method of correcting surveys taken with the compass, to fit them for calculation—a short method of finding the angles from the courses, and *vice versa*—the method of surveying with the compass through any mine or iron works, and to correct the deflections of the needle by attraction—description of an instrument by the help of which any one may measure a map by inspection, without calculation—a new and short method of calculation, wherein fewer figures are used—the method of correcting the diurnal variation of the needle—various methods of plotting and embellishing maps—the most correct method of laying off plots with the pole, etc.—description of a new compass contrived by the author, etc., etc.

Railroad Engineer's Pocket Companion for the Field.

By W. Griswold. 12mo., tucks..........................$1.25

Regnault. Elements of Chemistry.

By M. V. Regnault. Translated from the French by T. Forrest Betton, M.D., and edited, with notes, by James C. Booth, Melter and Refiner U. S. Mint, and William L. Faber, Metallurgist and Mining Engineer. Illustrated by nearly 700 wood engravings. Comprising nearly 1,500 pages. In two volumes, 8vo., cloth...................$10 00

Rural Chemistry;

An Elementary Introduction to the Study of the Science, in its relation to Agriculture and the Arts of Life. By Edward Solly, Professor of Chemistry in the Horticultural Society of London. From the third improved London edition. 12mo..$1.50

Shunk. A Practical Treatise

On Railway Curves, and Location for Young Engineers. By Wm. F. Shunk, Civil Engineer. 12mo...........$1.00

Strength and Other Properties of Metals;

Reports of Experiments on the Strength and other Properties of Metals for Cannon. With a Description of the Machines for Testing Metals, and of the Classification of Cannon in service. By Officers of the Ordnance Department U. S. Army. By authority of the Secretary of War. Illustrated by 25 large steel plates. In one volume, quarto..$10.00

The best Treatise on Cast-iron extant.

Tables Showing the Weight

OF ROUND, SQUARE AND FLAT BAR IRON, STEEL, etc., by Measurement. Cloth.. 50

Taylor. Statistics of Coal;

Including Mineral Bituminous Substances employed in Arts and Manufactures; with their Geographical, Geological and Commercial Distribution, and Amount of Production and Consumption on the American Continent. With Incidental Statistics of the Iron Manufacture. By R. C. Taylor. Second edition, revised by S. S. Haldeman. Illustrated by five Maps and many Wood Engravings. 8vo., cloth..$6.00

Templeton. The Practical Examinator on Steam and the Steam Engine;

With Instructive References relative thereto, arranged for the use of Engineers, Students, and others. By Wm. Templeton, Engineer. 12mo.................................. $1.25

This work was originally written for the author's private use. He was prevailed upon by various Engineers, who had seen the notes, to consent to its publication, from their eager expression of belief that it would be equally useful to them as it had been to himself.

Tin and Sheet Iron Worker's Instructor;

Comprising complete Descriptions of the necessary Patterns and Machinery, and the Processes of Calculating Dimensions, Cutting, Joining, Raising, Soldering, etc. etc. With numerous Illustrations.........................$2.50

Treatise (A) on a Box of Instruments,

And the Slide Rule; with the Theory of Trigonometry and Logarithms, including Practical Geometry, Surveying, Measuring of Timber, Cask and Malt Gauging, Heights and Distances. By Thomas Kentish. In one volume, 12mo...$1.25

A volume of inestimable value to Engineers, Gaugers, Students, and others.

Turnbull. The Electro-Magnetic Telegraph;

With an Historical Account of its Rise, Progress, and Present Condition. Also, Practical Suggestions in regard to Insulation and Protection from the Effects of Lightning. Together with an Appendix containing several important Telegraphic Devices and Laws. By Lawrence Turnbull, M. D., Lecturer on Technical Chemistry at the Franklin Institute. Second edition. Revised and improved. Illustrated by numerous Engravings. 8vo..$2.50

Turner's (The) Companion;

Containing Instruction in Concentric, Elliptic and Eccentric Turning; also various Steel Plates of Chucks, Tools and Instruments; and Directions for Using the Eccentric Cutter, Drill, Vertical Cutter and Rest; with Patterns and Instructions for working them. 12mo., cloth.. $1.25

Weatherley (Henry). Treatise on the Art of Boiling Sugar, Crystallizing, Lozenge making, Comfits, Gum Goods,

12mo...$2.00

Williams. On Heat and Steam;

Embracing New Views of Vaporization, Condensation, and Expansion. By Charles Wye Williams. Illustrated. 8vo..$3.50

SOCIAL SCIENCE.

THE WORKS OF HENRY C. CAREY.

"I challenge the production from among the writers on political economy of a more learned, philosophical, and convincing speculator on that theme, than my distinguished fellow-citizen, Henry C. Carey. The works he has published in support of the protective policy, are remarkable for profound research, extensive range of inquiry, rare logical acumen, and a consummate knowledge of history."—*Speech of Hon. Edward Joy Morris, in the House of Representatives of the United States, February* 2, 1859.

THE WORKS OF HENRY C. CAREY.

"Henry C. Carey, the best known and ablest economist of North America. * * * * * 'In Europe he is principally known by his striking and original attacks, based upon the peculiar advantages of American experience, on some of the principal doctrines, especially Malthus' 'Theory of Population' and Ricardo's teachings. His views have been largely adopted and thoroughly discussed in Europe."—"*The German Political Lexicon,*" *Edited by Bluntschli and Brater. Leipsic,* 1858.

"We believe that your labors mark an era in the science of political economy. To your researches and lucid arguments are we indebted for the explosion of the absurdities of Malthus, Say, and Ricardo, in regard to the inability of the earth to meet the demands of a growing population. American industry owes you a debt which cannot be repaid, and which it will ever be proud to acknowledge.—*From a Letter of Hon. George W. Scranton, M. C., Hon. William Jessup, and over sixty influential citizens of Luzerne County, Pennsylvania, to Henry C. Carey, April* 3, 1859.

Financial Crises;

Their Causes and Effects. 8vo., paper........................ 25

French and American Tariffs,

Compared in a Series of Letters addressed to Mons. M. Chevalier. 8vo., paper.. 25

Harmony (The) of Interests;

Agricultural, Manufacturing and Commercial. 8vo., paper.. 75
Cloth. $1.50

"We can safely recommend this remarkable work to all who wish to investigate the causes of the progress or decline of industrial communities."—*Blackwood's Magazine.*

Letters to the President of the United States.

8vo., Paper.. 50

Miscellaneous Works;

Comprising "Harmony of Interests," "Money," "Letters to the President," "French and American Tariffs," and "Financial Crises." One volume, 8vo. $3.00

Money; A Lecture

Before the New York Geographical and Statistical Society. 8vo., paper.. 25

THE WORKS OF HENRY C. CAREY.

Past (The), the Present, and the Future.

8vo.	$2.50
12mo.	$1.50

"Full of important facts bearing on topics that are now agitating all Europe. * * * These quotations will only whet the appetite of the scientific reader to devour the whole work. It is a book full of valuable information."—*Economist.*

"Decidedly a book to be read by all who take an interest in the progress of social science."—*Spectator.*

"A Southern man myself, never given to tariff doctrines, I confess to have been convinced by his reasoning, and, thank Heaven, have not now to learn the difference between dogged obstinacy and consistency. 'Ye gods, give us but light!' should be the motto of every inquirer after truth, but for far different and better purposes than that which prompted the exclamation."—*The late John S. Skinner.*

"A volume of extensive information, deep thought, high intelligence, and moreover of material utility."—*London Morning Advertiser.*

"Emanating from an active intellect, remarkable for distinct views and sincere convictions."—*Britannia.*

"'The Past, Present, and Future,' is a vast summary of progressive philosophy, wherein he demonstrates the benefit of political economy in the onward progress of mankind, which, ruled and directed by overwhelming influences of an exterior nature, advances little by little, until these exterior influences are rendered subservient in their turn, to increase as much as possible the extent of their wealth and riches."—*Dictionnaire Universel des Contemporains. Par G. Vapereau. Paris,* 1858.

Principles of Social Science.

Three volumes, 8vo., cloth.	$10.00

CONTENTS.—Volume I. Of Science and its Methods—Of Man, the Subject of Social Science—Of Increase in the Numbers of Mankind—Of the Occupation of the Earth—Of Value—Of Wealth—Of the Formation of Society—Of Appropriation—Of Changes of Matter in Place—Of Mechanical and Chemical Changes in the Forms of Matter. Volume II. Of Vital Changes in the Form of Matter—Of the Instrument of Association. Volume III. Of Production and Consumption—Of Accumulation—Of Circulation—Of Distribution—Of Concentration and Centralization—Of Competition—Of Population—Of Food and Population—Of Colonization—Of the Malthusian Theory—Of Commerce—Of the Societary Organization—Of Social Science.

"I have no desire here to reproach Mr. Malthus with the extreme lightness of his scientific baggage. In his day, biology, animal and vegetable chemistry, the relations of the various portions of the human organism, etc. etc., had made but little progress, and it is to the general ignorance in reference to these questions that we must, as I think, look for explanation of the fact that he should, with so much confidence, in reference to so very grave a subject, have ventured to suggest a formula so arbitrary in its character, and one whose hollowness becomes now so clearly manifest. Mr. Carey's advantage over him, both as to facts and logic, is certainly due in great part to the progress that has since been made in all the sciences connected with life; but then, how admirably has he profited of them! How entirely is he *au courant* of all these branches of knowledge which, whether directly or indirectly, bear upon his subject! With what skill does he ask of each and every of them all that it can be made to furnish, whether of facts or arguments! With what elevated views, and what amplitude of means, does he go forward in his work! Above all, how thorough in his scientific caution! Accumulating inductions, and presenting for consideration facts the most undoubted and probabilities of the highest kind, he yet affirms nothing, contenting himself with showing that his opponent had no good reason for affirming the nature of the progression, nor the time of duplication, nor the generalization which takes the facts of an individual case and deduces from them a law for every race, every climate, every civilization, every condition, moral or physical, permanent and transient, healthy or unhealthy, of the various populations of the many countries of the world. Then, having reduced the theory to the level of a mere hypothesis, he crushes it to atoms under the weight of facts."—*M. De Fontenay in the "Journal des Economistes." Paris, September,* 1862.

"This book is so abundantly full of notices, facts, comparisons, calculations, and arguments, that too much would be lost by laying a part of it before the eye of the reader. The work is vast and severe in its conception and aim, and is far removed from the common run of the books on similar subjects."—*Il Mondo Letterario, Turin.*

"In political economy, America is represented by one of the strongest and most original writers of the age, Henry C. Carey, of Philadelphia. * * * * * * * * * * *

"His theory of Rents is regarded as a complete demonstration that the popular views derived from Ricardo are erroneous; and on the subject of Protection, he is generally confessed to be the master-thinker of his country."—*Westminster Review.*

"Both in America and on the Continent, Mr. Henry Carey has acquired a great name as a political economist. * * * * *

"His refutation of Malthus and Ricardo we consider most triumphant."—*London Critic.*

"Mr. Carey began his publication of Principles twenty years ago; he is certainly a mature and deliberate writer. More than this, he is readable: his pages swarm with illustrative facts and with American instances. * * * * * * * * * * * *

"We are in great charity with books which, like Mr. Carey's, theorize with excessive boldness, when the author, as does Mr. Carey, possesses information and reasoning power."—*London Athenæum.*

"Those who would fight against the insatiate greed and unscrupulous misrepresentations of the Manchester school, which we have frequently exposed, without any of their organs having ever dared to make reply, will find in this and Mr. Carey's other works an immense store of arms and ammunition. * * * * * * * *

"An author who has, among the political economists of Germany and France, numerous readers, is worth attentive perusal in England."—*London Statesman.*

"Of all the varied answers to the old cry of human nature, 'Who will show us any good?' none are more sententious than Mr. Carey's. He says to Kings, Presidents, and People, 'Keep the nation at work, and the greater the variety of employments the better.' He is seeking and elucidating the great radical laws of matter as regards man. He is at once the apostle and evangelist of temporal righteousness." —*National Intelligencer.*

"A work which we believe to be the greatest ever written by an American, and one which will in future ages be pointed out as the most successful effort of its time to form the great *scientia scientiarum.*" —*Philadelphia Evening Bulletin.*

THE WORKS OF HENRY C. CAREY.

The Slave Trade, Domestic and Foreign;

Why it Exists, and How it may be Extinguished. 12mo., cloth...$1.50

CONTENTS.—The Wide Extent of Slavery—Of Slavery in the British Colonies—Of Slavery in the United States—Of Emancipation in the British Colonies—How Man passes from Poverty and Slavery toward Wealth and Freedom—How Wealth tends to Increase—How Labor acquires Value and Man becomes Free—How Man passes from Wealth and Freedom toward Poverty and Slavery—How Slavery grew, and How it is now maintained in the West Indies—How Slavery grew, and is maintained in the United States—How Slavery grows in Portugal and Turkey—How Slavery grows in India—How Slavery grows in Ireland and Scotland—How Slavery grows in England—How can Slavery be extinguished?—How Freedom grows in Northern Germany—How Freedom grows in Russia—How Freedom grows in Denmark—How Freedom grows in Spain and Belgium—Of the Duty of the People of the United States—Of the Duty of the People of England.

"As a philosophical writer, Mr. Carey is remarkable for the union of comprehensive generalizations with a copious induction of facts. His research of principles never leads him to the neglect of details, nor is his accumulation of instances ever at the expense of universal truth. He is, doubtless, intent on the investigation of laws, as the appropriate aim of science, but no passion for theory seduces him into the region of pure speculation. His mind is no less historical than philosophical, and had he not chosen the severer branch in which his studies have borne such excellent fruit, he would have attained an eminent rank among the historians from whom the literature of our country has received such signal illustration."—*New York Tribune.*

French Politico-Economic Controversy,

Between the Supporters of the Doctrines of Carey and of those of Ricardo and Malthus. By MM. De Fontenay, Dupuit, Baudrillart, and others. Translated from the "Journal des Economistes," 1862–63. *(In press.)*

Protection of Home Labor and Home Productions

Necessary to the Prosperity of the American Farmer By H. C. Baird. Paper.. 13

Smith. A Manual of Political Economy.

By E. Peshine Smith. 12mo., cloth..........................$1.25

Phillips Library
3 6234 00137823 4